



- (51) **International Patent Classification:**  
*C08L 67/02* (2006.01)
- (21) **International Application Number:**  
PCT/US2012/021022
- (22) **International Filing Date:**  
12 January 2012 (12.01.2012)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**  
61/433,337 17 January 2011 (17.01.2011) US  
13/097,696 29 April 2011 (29.04.2011) US
- (71) **Applicant:** EASTMAN CHEMICAL COMPANY [US/US]; 200 South Wilcox Drive, Kingsport, TN 37660 (US).
- (72) **Inventors:** STACK, Gary, Michael; P.O. Box 6446, Kingsport, TN 37663 (US). HALE, Wesley, Raymond; 801 Wood Court, Kingsport, TN 37663 (US). DONELSON, Michael, Eugene; 5027 Country Drive, Kingsport, TN 37664 (US). MAINE, James, Collins; 407 Deerfield Circle, Church Hill, TN 37642 (US). HAWKINS, Gary, Stuart; 4 Osprey Point, Johnson City, TN 37604 (US). HOWELL, Jeff, Scott; 249 Douglas Chapel Road, Jonesborough, TN 37659 (US).
- (74) **Agent:** BOSHEARS, Betty, J.; P.O. Box 511, Kingsport, TN 37662-5075 (US).
- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, ZA, ZM, ZW.
- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:**  
— with international search report (Art. 21(3))

(54) **Title:** HAZE REDUCTION FOR BLENDS OF AROMATIC-ALIPHATIC POLYESTERS WITH ALIPHATIC POLYESTERS AND ANTIMICROBIAL ADDITIVES

(57) **Abstract:** This invention relates to a polymer blend comprising: (A) about 1% by weight to about 99% by weight of at least one polymer (A) comprising terephthalic acid residues, 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and 1,4-cyclohexanedimethanol residues; (B) about 1 % by weight to about 99% by weight of at least one polymer (B) comprising 1, 4-cyclohexanedicarboxylic acid residues and 1,4-cyclohexanedimethanol residues, and (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent; said weight percentages being based on the total weight of the polymer blend.



## **HAZE REDUCTION FOR BLENDS OF AROMATIC-ALIPHATIC POLYESTERS WITH ALIPHATIC POLYESTERS AND ANTIMICROBIAL ADDITIVES**

### **BACKGROUND OF THE INVENTION**

**[0001]** The healthcare industry has a need for clarity in various medical device parts and medical packaging. Other industries benefit from clarity of polymer blends as well. Part clarity improves the ability of the health care professional to observe fluid paths and to detect potential biofilm development. The healthcare industry also has a need to reduce hospital acquired infections by incorporating antimicrobial additives into various medical devices, packaging, housings, curtains and the like. Clarity in polymers with antimicrobial additives is difficult to achieve as the additives typically create haze when compounded into the polymer. Health care institutions often have had to sacrifice clarity to use parts with antimicrobial additives. Parts used in these applications typically range from translucent to opaque.

### **SUMMARY OF THE INVENTION**

**[0002]** This invention relates to a polymer blend comprising:  
(A) about 1% by weight to about 99% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues,

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wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 99% by weight of at least one polymer comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;

said weight percentages being based on the total weight of the polymer blend.

**[0003]** A polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer

(A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

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wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;

said weight percentages being based on the total weight of the polymer blend.

**[0004]** A polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer

(A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 20 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 65 to 80 mole % of 1,4-cyclohexanedimethanol residues,

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wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;

said weight percentages being based on the total weight of the polymer blend.

**[0005]** A polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer

(A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

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wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;

said weight percentages being based on the total weight of the polymer blend.

**[0006]** This invention relates to a polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer

(A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues,

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wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof;

said weight percentages being based on the total weight of the polymer blend.

**[0007]** A polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer

(A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

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(b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

(1) a dicarboxylic acid component comprising:

(a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;

(b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and

(c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof;

said weight percentages being based on the total weight of the polymer blend.

**[0008]** A polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer

(A) comprising:

(1) a dicarboxylic acid component comprising:

(a) 70 to 100 mole % of terephthalic acid residues;

(b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and

(c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising:



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- (a) 20 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 65 to 80 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
- (B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:
- (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
    - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
    - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
- (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend.

**[0009]** A polymer blend comprising:

- (A) about 1% by weight to about 99% by weight of at least one polymer (A) comprising:
  - (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of terephthalic acid residues;
    - (b) 0 to 30 mole % of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
    - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and

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- (2) a glycol component comprising:
- (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,
- wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
- (B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:
- (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
    - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
    - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues,
- wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
- (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend.
- [0010]** This invention relates to a polymer blend comprising:
- (A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and

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- (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
  - (B) about 1% by weight to about 49% by weight of at least one polymer (B) comprising:
    - (1) a dicarboxylic acid component comprising:
      - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
      - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
      - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
    - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
  - (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;
- said weight percentages being based on the total weight of the polymer blend.

**[0011]** A polymer blend comprising:

- (A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:
  - (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of terephthalic acid residues;
    - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and

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- (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
  - (B) about 1% by weight to about 49% by weight of at least one polymer (B), wherein polymer (B) comprises at least one polyester which comprises:
    - (1) a dicarboxylic acid component comprising:
      - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
      - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
      - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
    - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
  - (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;
- said weight percentages being based on the total weight of the polymer blend.

**[0012]** A polymer blend comprising:

- (A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:
  - (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of terephthalic acid residues;
    - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and

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- (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
  - (B) about 1% by weight to about 49% by weight of at least one polymer (B) comprising:
    - (1) a dicarboxylic acid component comprising:
      - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
      - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
      - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
    - (2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
  - (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;
- said weight percentages being based on the total weight of the polymer blend.

**[0013]** This invention relates to a polymer blend comprising:

- (A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:
  - (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of terephthalic acid residues;
    - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and

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- (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
- (B) about 1% by weight to about 49% by weight of at least one polymer (B) comprising:
  - (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
    - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
    - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
- (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend.

**[0014]** A polymer blend comprising:

- (A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:
  - (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of terephthalic acid residues;

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- (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
  - (B) about 1% by weight to about 49% by weight of at least one polymer (B) comprising:
    - (1) a dicarboxylic acid component comprising:
      - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
      - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
      - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
    - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
  - (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof;
- said weight percentages being based on the total weight of the polymer blend.

**[0015]** A polymer blend comprising:

- (A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:
  - (1) a dicarboxylic acid component comprising:

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- (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
- (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,
- wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
- (B) about 1% by weight to about 49% by weight of at least one polymer (B) comprising:
- (1) a dicarboxylic acid component comprising:
- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues,
- wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
- (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof;
- said weight percentages being based on the total weight of the polymer blend.
- [0016]** This invention relates to a polymer blend comprising:
- (A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:



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- (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of terephthalic acid residues;
    - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
    - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
  - (B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:
    - (1) a dicarboxylic acid component comprising:
      - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
      - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
      - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
    - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
  - (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;
- said weight percentages being based on the total weight of the polymer blend.
- [0017]** A polymer blend comprising:
- (A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:

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- (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of terephthalic acid residues;
    - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
    - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
  - (B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:
    - (1) a dicarboxylic acid component comprising:
      - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
      - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
      - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
    - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
  - (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;
- said weight percentages being based on the total weight of the polymer blend.
- [0018]** A polymer blend comprising:
- (A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:

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- (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of terephthalic acid residues;
    - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
    - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
  - (B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:
    - (1) a dicarboxylic acid component comprising:
      - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
      - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
      - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
    - (2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
  - (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;
- said weight percentages being based on the total weight of the polymer blend.
- [0019]** This invention relates to a polymer blend comprising:
- (A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:

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- (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of terephthalic acid residues;
    - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
    - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
  - (B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:
    - (1) a dicarboxylic acid component comprising:
      - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
      - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
      - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
    - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
  - (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof;
- said weight percentages being based on the total weight of the polymer blend.

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**[0020]** A polymer blend comprising:

(A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of terephthalic acid residues;
- (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising:

- (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
- (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
- (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof;

said weight percentages being based on the total weight of the polymer blend.

**[0021]** A polymer blend comprising:

(A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

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(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend.

**[0022]** This invention relates to a polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer (A) comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of terephthalic acid residues;
- (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising:

- (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
- (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 99% by weight of at least one polymer comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
- (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

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wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;

said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0023]** A polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer

(A) comprising:

(1) a dicarboxylic acid component comprising:

(a) 70 to 100 mole % of terephthalic acid residues;

(b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and

(c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising:

(a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

(1) a dicarboxylic acid component comprising:

(a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;

(b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and

(c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and



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- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

- (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;

said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0024]** A polymer blend comprising:

- (A) about 1% by weight to about 99% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of terephthalic acid residues;  
(b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and  
(c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and

- (2) a glycol component comprising:

- (a) 20 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and  
(b) 65 to 80 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

- (B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;  
(b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and

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- (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

- (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;

said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0025]** A polymer blend comprising:

- (A) about 1% by weight to about 99% by weight of at least one polymer

(A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

- (B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;

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- (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;

said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0026]** This invention relates to a polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer

(A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:

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- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0027]** A polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

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(B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0028]** A polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 20 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 65 to 80 mole % of 1,4-cyclohexanedimethanol residues,

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wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof;

said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0029]** A polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer

(A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:

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- (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
- (B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:
- (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
    - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
    - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
- (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0030]** This invention relates to a polymer blend comprising:

(A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and

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- (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
  - (B) about 1% by weight to about 49% by weight of at least one polymer (B) comprising:
    - (1) a dicarboxylic acid component comprising:
      - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
      - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
      - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
    - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
  - (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;
- said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0031]** A polymer blend comprising:

- (A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:
  - (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of terephthalic acid residues;



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- (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
  - (B) about 1% by weight to about 49% by weight of at least one polymer (B), wherein polymer (B) comprises at least one polyester which comprises:
    - (1) a dicarboxylic acid component comprising:
      - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
      - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
      - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
    - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
  - (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;
- said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0032]** A polymer blend comprising:

- (A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:
  - (1) a dicarboxylic acid component comprising:

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- (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
- (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,
- wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
- (B) about 1% by weight to about 49% by weight of at least one polymer (B) comprising:
- (1) a dicarboxylic acid component comprising:
- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues,
- wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
- (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;
- said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.
- [0033]** This invention relates to a polymer blend comprising:
- (A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:

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- (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of terephthalic acid residues;
    - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
    - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues,wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
- (B) about 1% by weight to about 49% by weight of at least one polymer (B) comprising:
- (1) a dicarboxylic acid component comprising:
    - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
    - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
    - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
  - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,
- wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
- (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0034]** A polymer blend comprising:

(A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of terephthalic acid residues;
- (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising:

- (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
- (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 49% by weight of at least one polymer (B) comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
- (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof;

said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0035]** A polymer blend comprising:

(A) about 51% by weight to about 99% by weight of at least one polymer (A) comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of terephthalic acid residues;
- (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising:

- (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
- (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 49% by weight of at least one polymer (B) comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
- (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

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(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0036]** This invention relates to a polymer blend comprising:  
(A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

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wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;

said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0037]** A polymer blend comprising:

(A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of terephthalic acid residues;
- (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising:

- (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
- (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
- (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

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- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

- (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;

said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0038]** A polymer blend comprising:

- (A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of terephthalic acid residues;  
(b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and  
(c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and

- (2) a glycol component comprising:

- (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and  
(b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

- (B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;  
(b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and



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- (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

- (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;

said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0039]** This invention relates to a polymer blend comprising:

- (A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

- (B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;

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- (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0040]** A polymer blend comprising:

(A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:

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- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0041]** A polymer blend comprising:

(A) about 60% by weight to about 90% by weight of at least one polymer (A) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of terephthalic acid residues;
  - (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising:
  - (a) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
  - (b) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

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(B) about 10% by weight to about 40% by weight of at least one polymer (B) comprising:

- (1) a dicarboxylic acid component comprising:
  - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
  - (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
  - (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
- (2) a glycol component comprising 80 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend; wherein said blend has a haze value of less than 50%.

**[0042]** In one aspect of the invention, each embodiment of the invention can have a haze value of from 0 to 65, or 0 to 60, or 0 to 55, or 0 to 50, or 0 to 45, or 0 to 40, or 0 to 35, or 0 to 20, or 0 to 15, or 1 to 20, or 1 to 15, or 5 to 20, or 5 to 15, or 10 to 20, or 10 to 16, or 10 to 15 as determined by ASTM Method D1003 or by other methods described herein. In connection with any one of these haze values, in one embodiment, the percent transmittance of the blend can be at least 50% or at least 60% or at least 70%. In one embodiment, the haze value can be measured on 1/8 thick specimens.

**[0043]** In one aspect of the invention, the blends of the invention can have a haze value of less than 65% at up to 8% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

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**[0044]** In one aspect of the invention, the blends of the invention can have a haze value of less than 65% at up to 7% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0045]** In one aspect of the invention, the blends of the invention can have a haze value of less than 65% at up to 6% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0046]** In one aspect of the invention, the blends of the invention can have a haze value of less than 65% at up to 5% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0047]** In one aspect of the invention, the blends of the invention can have a haze value of less than 65% at up to 4% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0048]** In one aspect of the invention, the blends of the invention can have a haze value of less than 65% at up to 3% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0049]** In one aspect of the invention, the blends of the invention can have a haze value of less than 65% at up to 2% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0050]** In one aspect of the invention, the blends of the invention can have a haze value of less than 65% at up to 1.5% by weight of at least one

antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0051]** In one aspect of the invention, the blends of the invention can have a haze value of less than 65% at up to 1% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0052]** In one aspect of the invention, the polymer blends of the invention can have a haze value of less than 50 % at up to 8 % by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the polymer blend.

**[0053]** In one aspect of the invention, the polymer blends of the invention can have a haze value of less than 50 % at up to 7 % by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the polymer blend.

**[0054]** In one aspect of the invention, the polymer blends of the invention can have a haze value of less than 50 % at up to 6 % by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the polymer blend.

**[0055]** In one aspect of the invention, the polymer blends of the invention can have a haze value of less than 50 % at up to 5 % by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the

weight percentage of the antimicrobial agent is based on the total weight of the polymer blend.

**[0056]** In one aspect of the invention, the blends of the invention can have a haze value of less than 50% at up to 4% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0057]** In one aspect of the invention, the polymer blends of the invention can have a haze value of less than 50 % at up to 3 % by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the polymer blend.

**[0058]** In one aspect of the invention, the blends of the invention can have a haze value of less than 50% at up to 2% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0059]** In one aspect of the invention, the blends of the invention can have a haze value of less than 50 % at up to 1.5% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0060]** In one aspect of the invention, the blends of the invention can have a haze value of less than 50 % at up to 1% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0061]** In one aspect of the invention, the blends of the invention can have a haze value of less than 40% at up to 4% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM

Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0062]** In one aspect of the invention, the blends of the invention can have a haze value of less than 40% at up to 3% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0063]** In one aspect of the invention, the blends of the invention can have a haze value of less than 40% at up to 2% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0064]** In one aspect of the invention, the blends of the invention can have a haze value of less than 40 % at up to 1.5% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0065]** In one aspect of the invention, the blends of the invention can have a haze value of less than 40 % at up to 1% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0066]** In one aspect of the invention, the blends of the invention can have a haze value of less than 30% at up to 4% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0067]** In one aspect of the invention, the blends of the invention can have a haze value of less than 30% at up to 3% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM



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Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0068]** In one aspect of the invention, the blends of the invention can have a haze value of less than 30% at up to 2% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0069]** In one aspect of the invention, the blends of the invention can have a haze value of less than 30 % at up to 1.5% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0070]** In one aspect of the invention, the blends of the invention can have a haze value of less than 30 % at up to 1% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0071]** In one aspect of the invention, the blends of the invention can have a haze value of less than 20% at up to 4% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0072]** In one aspect of the invention, the blends of the invention can have a haze value of less than 20% at up to 3% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0073]** In one aspect of the invention, the blends of the invention can have a haze value of less than 20% at up to 2% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM

Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0074]** In one aspect of the invention, the blends of the invention can have a haze value of less than 20 % at up to 1.5% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0075]** In one aspect of the invention, the blends of the invention can have a haze value of less than 20 % at up to 1% by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the blend.

**[0076]** In one aspect of the invention, each embodiment of the invention can have a b\* value of from -10 to 10 or from -5 to 10 or 0 to 10 or -10 or less than 5 or 1 to 5 or 1 to 10 determined as described herein.

**[0077]** These polymer blends provide a unique combination at least two of good clarity, good haze values, good impact strength, good chemical resistance and good microbial resistance.

## **DETAILED DESCRIPTION**

**[0078]** This invention relates to a blend aliphatic-aromatic polyesters with aliphatic polyesters and antimicrobial additives.

**[0079]** More particularly, this invention relates to a polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer

(A) comprising:

(1) a dicarboxylic acid component comprising:

(a) 70 to 100 mole % of terephthalic acid residues;

(b) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

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- (c) 0 to 30 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and
  - (2) a glycol component comprising:
    - (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
    - (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;
  - (B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:
    - (1) a dicarboxylic acid component comprising:
      - (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
      - (b) 0 to 30 mole % of at least one aromatic dicarboxylic acid residues having up to 20 carbon atoms; and
      - (c) 0 to 30 mole % of at least one modifying aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and
    - (2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues, wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
  - (C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent;
- said weight percentages being based on the total weight of the polymer blend.

**[0080]** Polymers A and B are polyesters as will be described more fully herein. The term “polyester”, as used herein, is intended to include “copolyesters” and is understood to mean a synthetic polymer prepared by the polycondensation of one or more difunctional carboxylic acids with one or more difunctional hydroxyl compounds. Typically the difunctional carboxylic acid is a dicarboxylic acid and the difunctional hydroxyl compound is a dihydric alcohol such as, for example, glycols and diols. The term “residue”, as used herein,

means any organic structure incorporated into a polymer or plasticizer through a polycondensation reaction involving the corresponding monomer. The term "repeating unit", as used herein, means an organic structure having a dicarboxylic acid residue and a diol residue bonded through a carbonyloxy group. Thus, the dicarboxylic acid residues may be derived from a dicarboxylic acid monomer or its associated acid halides, esters, salts, anhydrides, or mixtures thereof. As used herein, therefore, the term dicarboxylic acid 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.

**[0081]** The polyester(s) included in the present invention contain substantially equal molar proportions of acid residues (100 mole%) and diol residues (100 mole%) which react in substantially equal proportions such that the total moles of repeating units is equal to 100 mole%. 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% adipic acid, based on the total acid residues, means that the copolyester contains 30 mole% adipic residues out of a total of 100 mole% acid residues. Thus, there are 30 moles of adipic residues among every 100 moles of acid residues. In another example, a copolyester containing 30 mole% 1,6-hexanediol, based on the total diol residues, means that the copolyester contains 30 mole% 1,6-hexanediol residues out of a total of 100 mole% diol residues. Thus, there are 30 moles of 1,6-hexanediol residues among every 100 moles of diol residues.

**[0082]** As used herein, the term "terephthalic acid" is intended to include terephthalic acid itself and residues thereof as well as any derivative of terephthalic acid, including its associated acid halides, esters, half-esters, salts, half-salts, anhydrides, mixed anhydrides, and/or mixtures thereof or residues thereof useful in a reaction process with a diol to make polyester.

**[0083]** 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, optionally all, in the case of Polymer A) of the aromatic dicarboxylic acid component, if any, used to form the polyesters useful in the invention. In certain embodiments, terephthalic acid residues can make up a portion (or optionally all, in the case of Polymer A) of the aromatic dicarboxylic acid component, if any, used to form the polyesters useful in the invention. For purposes of this disclosure, the terms "terephthalic acid" and "dimethyl terephthalate" are used interchangeably herein. In one embodiment, dimethyl terephthalate is part (or optionally all, in the case of Polymer A) of the aromatic dicarboxylic acid component, if any, used to make the polyesters useful in the present invention.

**[0084]** The dicarboxylic acid component of the polymers A or B useful in the invention can comprise up to 30 mole %, or up to 25 mole %, or up to 20 mole %, or up to 15 mole %, or up to 10 mole %, or up to 5 mole %, or up to 1 mole % of one or more 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, 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, terephthalic acid (for polymer B), 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. In one embodiment, for polymer B, the modifying aromatic dicarboxylic acid is terephthalic acid.

**[0085]** The carboxylic acid component of the polyesters useful in the invention can be further modified with up to 30 mole %, up to 20 mole %, up to 10 mole %, 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, or for Polymer A, 1, 4-cyclohexanedicarboxylic acid. Certain embodiments can also comprise 0.01 to 40 mole %, 0.01 to 30 mole %, 0.01 to 20 mole %, 0.01 to 10 mole %, 0.1 to 40 mole %, 0.1 to 30 mole %, 0.1 to 20 mole %, 0.1 to 10 mole %, 1 to 40 mole %, 1 to 30 mole %, 1 to 20 mole %, 1 to 10 mole %, 5 to 40 mole %, 5 to 30 mole %, 5 to 20 mole %, or 5 to 10 mole %, of one or more modifying aliphatic dicarboxylic acids. Yet another embodiment contains 0 mole % modifying aliphatic dicarboxylic acids. The total mole % of the dicarboxylic acid component is equal to 100 mole %. In one embodiment, adipic acid and/or glutaric acid are provided in the modifying aliphatic dicarboxylic acid component of the invention.

**[0086]** Esters of 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.

**[0087]** For the desired polyester, the molar ratio of cis/trans 2,2,4,4-tetramethyl-1,3-cyclobutanediol can vary from the pure form of each and mixtures thereof. In one embodiment, the molar ratio of cis/trans 2,2,4,4-tetramethyl-1,3-cyclobutanediol can vary within the range of 50/50 to 0/100, for example, between 40/60 to 20/80. In an additional embodiment, the molar ratio of trans/cis 2,2,4,4-tetramethyl-1,3-cyclobutanediol can vary within the range of 50/50 to 0/100, for example, between 40/60 to 20/80.

**[0088]** The cyclohexanedimethanol may be cis, trans, or a mixture thereof, for example, a cis/trans ratio of 60:40 to 40:60 or a cis/trans ratio of 70:30 to 30:70. In one embodiment, 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.

**[0089]** Any of isomers of cyclohexanedimethanol or mixtures thereof may be present in the glycol component of any embodiment of this invention.

**[0090]** In one embodiment, the glycol component of Polymer A of the invention can contain 0 to 55 mole % of one or more modifying glycols. In one embodiment, the glycol component of Polymer B of the invention can contain 0 to 50 mole % or 1 to 50 mole % glycols. In one embodiment, either polymer A or polymer B can contain 1 to 45 mole % of one or more modifying glycols. In one embodiment, either polymer A or polymer B can contain 1 to 30 mole % of one or more modifying glycols. In one embodiment, either polymer A or polymer B can contain 1 to 20 mole % of one or more modifying glycols. In another embodiment, either polymer A or polymer B can contain 25 mole % or less of one or more modifying glycols. In yet another embodiment, either polymer A or polymer B can contain less than 15 mole % modifying glycols. In one embodiment, either polymer A or polymer B can contain less than 10 mole % of one or more modifying glycols. In one embodiment, either polymer A or polymer B can contain less than 5 mole % of one or more modifying glycols. In one embodiment, either polymer A or polymer B can contain 0.01 to 10 mole % of one or more modifying glycols. In one embodiment, polymer B can contain 0 mole % of one or more modifying glycols.

**[0091]** Modifying glycols useful in the polymers A useful in the invention refer to diols other than 2,2,4,4-tetramethyl-1,3-cyclobutanediol and cyclohexanedimethanol and can contain 2 to 16 carbon atoms. Modifying glycols useful in the polymers B useful in the invention refer to diols other than cyclohexanedimethanol and can contain 2 to 16 carbon atoms. Examples of suitable modifying glycols include, but are not limited to, ethylene glycol, diethylene glycol, 1,2-propanediol, 1,3-propanediol, neopentyl glycol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, polytetramethylene glycol, polyethylene glycol, and/or mixtures thereof. However, for polymer B, 2,2,4,4-tetramethyl-1,3-cyclobutanediol can be also be a modifying glycol. In another embodiment, the modifying glycols include, but are not limited to, at least one of 1,3-propanediol and 1,4-butanediol. In one embodiment, at least one modifying glycol is diethylene glycol. In one embodiment, the diethylene glycol is not added as a separate monomer but is formed during polymerization.

**[0092]** For embodiments of the invention, the polymers A and B useful in the invention may exhibit at least one of the following inherent viscosity ranges as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C: 0.35 to 1.2 dL/g; 0.35 to 1 dL/g; 0.35 to 0.80 dL/g; 0.35 to 0.75 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; 0.50 to 1.2 dL/g; 0.50 to 1 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 0.70 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; 0.60 to 1.2 dL/g; 0.60 to 1 dL/g; 0.60 to 0.80 dL/g; 0.60 to 0.75 dL/g; 0.60 to 0.70 dL/g; or 0.60 to 0.68 dL/g;

**[0093]** It is contemplated that polymers A and B useful in the invention can possess at least one of the inherent viscosity ranges described herein in combination with either specific or general embodiments of the invention.

**[0094]** The polyesters (polymers A and B) useful in the polymer blends of the invention can comprise from 0 to 10 mole percent, for example, from 0.01 to 5 mole percent, from 0.01 to 1 mole percent, from 0.05 to 5 mole percent, from 0.05 to 1 mole percent, or from 0.1 to 0.7 mole percent, or from 0.1 to 0.5 mole percent, based on the total mole percentages of either the diol or diacid residues; respectively, 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. In certain embodiments, the branching monomer or agent may be added prior to and/or during and/or after the polymerization of the polyester. The polyester(s) useful in the invention can thus be linear or branched.

**[0095]** 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 and the like. In one embodiment, the branching monomer residues can comprise 0.1 to 0.7 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 Nos. 5,654,347 and 5,696,176, whose disclosure regarding branching monomers is incorporated herein by reference.

**[0096]** The polyesters useful in the invention can comprise at least one chain extender. Suitable chain extenders include, but are not limited to, multifunctional (including, but not limited to, bifunctional) isocyanates, multifunctional epoxides, including for example ,epoxylated novolacs, and phenoxy resins. In certain embodiments, chain extenders may be added at the end of the polymerization process or after the polymerization process. If added after the polymerization process, chain extenders can be incorporated by compounding or by addition during conversion processes such as injection molding or extrusion. The amount of chain extender used can vary depending on the specific monomer composition used and the physical properties desired but is generally about 0.1 percent by weight to about 10 percent by weight, such as about 0.1 to about 5 percent by weight, based on the total weight of the polyester.

**[0097]** The blends of the invention may contain Polymer A or Polymer B in percentages by weight based on the total weight of the polymer blend as follows: 0.01% to 99%; or 1 to 99%; or 5 to 99%; or 10 to 99%; or 15 to 99%; or 20 to 99%; or 25 to 99%; or 30 to 99%; or 35 to 99%; or 40 to 99%; or 45 to 99%; or 50 to 99%; or 55 to 99%; or 60 to 99%; or 65 to 99%; or 70 to 99%; or 75 to 99%; or 80 to 99%; or 85 to 99%; or 90 to 99%; or 95 to 99%; or 0.01% to 95%; or 1 to 95%; or 5 to 95%; or 10 to 95%; or 15 to 95%; or 20 to 95%; or 25 to 95%; or 30 to 95%; or 35 to 95%; or 40 to 95%; or 45 to 95%; or 50 to 95%; or 55 to 95%; or 60 to 95%; or 65 to 95%; or 70 to 95%; or 75 to 95%; or 80 to 95%; or 85 to 95%; or 90 to 95%; or 0.01% to 90%; or 1 to 90%; or 5 to 90%; or 10 to 90%; or 15 to 90%; or 20 to 90%; or 25 to 90%; or 30 to 90%; or 35 to 90%; or 40 to 90%; or 45 to 90%; or 50 to 90%; or 55 to 90%; or 60 to 90%; or 65 to 90%; or 70 to 90%; or 75 to 90%; or 80 to 90%; or 85 to 90%; or 0.01% to 85%; or 1 to 85%; or 5 to 85%; or 10 to 85%; or 15 to 85%; or 20 to 85%; or 25 to 85%; or 30 to 85%; or 35 to 85%; or 40 to 85%; or 45 to 85%; or 50 to 85%; or 55 to 85%; or 60 to 85%; or 65 to 85%; or 70 to 85%; or 75 to 85%; or 80 to 85%; or 0.01% to 80%; or 1 to 80%; or 5 to 80%; or 10 to 80%; or 15 to 80%; or 20 to 80%; or 25 to 80%; or 30

to 80%; or 35 to 80%; or 40 to 80%; or 45 to 80%; or 50 to 80%; or 55 to 80%; or 60 to 80%; or 65 to 80%; or 70 to 80%; or 75 to 80%; 0.01% to 75%; or 1 to 75%; or 5 to 75%; or 10 to 75%; or 15 to 75%; or 20 to 75%; or 25 to 75%; or 30 to 75%; or 35 to 75%; or 40 to 75%; or 45 to 75%; or 50 to 75%; or 55 to 75%; or 60 to 75%; or 65 to 75%; or 70 to 75%; or 0.01% to 70%; or 1 to 70%; or 5 to 70%; or 10 to 70%; or 15 to 70%; or 20 to 70%; or 25 to 70%; or 30 to 70%; or 35 to 70%; or 40 to 70%; or 45 to 70%; or 50 to 70%; or 55 to 70%; or 60 to 70%; or 65 to 70%; or 0.01% to 65%; or 1 to 65%; or 5 to 65%; or 10 to 65%; or 15 to 65%; or 20 to 65%; or 25 to 65%; or 30 to 65%; or 35 to 65%; or 40 to 65%; or 45 to 65%; or 50 to 65%; or 55 to 65%; or 60 to 65%; or 0.01% to 60%; or 1 to 60%; or 5 to 60%; or 10 to 60%; or 15 to 60%; or 20 to 60%; or 25 to 60%; or 30 to 60%; or 35 to 60%; or 40 to 60%; or 45 to 60%; or 50 to 60%; or 55 to 60%; or 0.01% to 55%; or 1 to 55%; or 5 to 55%; or 10 to 55%; or 15 to 55%; or 20 to 55%; or 25 to 55%; or 30 to 55%; or 35 to 55%; or 40 to 55%; or 45 to 55%; or 50 to 55%; or 0.01% to 50%; or 1 to 50%; or 5 to 50%; or 10 to 50%; or 15 to 50%; or 20 to 50%; or 25 to 50%; or 30 to 50%; or 35 to 50%; or 40 to 50%; or 45 to 50%; or 0.01% to 45%; or 1 to 45%; or 5 to 45%; or 10 to 45%; or 15 to 45%; or 20 to 45%; or 25 to 45%; or 30 to 45%; or 35 to 45%; or 40 to 45%; or 0.01% to 40%; or 1 to 40%; or 5 to 40%; or 10 to 40%; or 15 to 40%; or 20 to 40%; or 25 to 40%; or 30 to 40%; or 35 to 40%; or 0.01% to 35%; or 1 to 35%; or 5 to 35%; or 10 to 35%; or 15 to 35%; or 20 to 35%; or 25 to 35%; or 30 to 35%; or 0.01% to 30%; or 1 to 30%; or 5 to 30%; or 10 to 30%; or 15 to 30%; or 20 to 30%; or 25 to 30%; or 0.01% to 25%; or 1 to 25%; or 5 to 25%; or 10 to 25%; or 15 to 25%; or 20 to 25%; or 0.01% to 20%; or 1 to 20%; or 5 to 20%; or 10 to 20%; or 15 to 20%; or 0.01% to 15%; or 1 to 15%; or 5 to 15%; or 10 to 15%; or 0.01% to 10%; or 1 to 10%; or 5 to 10%; or 0.01% to 5%. In another embodiment, the word "about" is inserted before each numerical value of each range.

**[0098]** The polymer blend of the invention also can contain any amount of any inorganic or organic antimicrobial agent. An antimicrobial agent is an agent or additive or compound that is effective for reducing or retarding or preventing growth of microorganisms including but not limited to bacteria or viruses. In one embodiment, the antimicrobial agent is present in the amount of about 0.01% by

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weight to about 20% by weight based on the total weight of the polymer blend. In one embodiment, the antimicrobial agent is present in the amount of about 0.25% by weight to about 20% by weight based on the total weight of the polymer blend. In one embodiment, the antimicrobial agent is present in the amount of about 0.25% by weight to about 10% by weight based on the total weight of the polymer blend. In one embodiment, the antimicrobial agent is present in the amount of about 0.5% by weight to about 10% by weight based on the total weight of the polymer blend. In one embodiment, the antimicrobial agent is present in the amount of about 0.5% by weight to about 5% by weight based on the total weight of the polymer blend.

**[0099]** Any antimicrobial agent known in the art is contemplated within the scope of this invention.

**[00100]** Certain examples of suitable inorganic antimicrobial agents include transition metal ion-based compounds, (e.g., silver, zinc, copper, gold, tin and platinum-based compounds). Examples of suitable silver-containing antimicrobial agents include silver sulfate, silver acetate, silver chloride, silver lactate, silver phosphate, silver stearate, silver thiocyanate, silver proteinate, silver carbonate, silver nitrate, silver sulfadiazine, silver alginate, silver nanoparticles, silver-substituted ceramic zeolites, silver complexed with calcium phosphates, silver-copper complexed with calcium phosphates, silver dihydrogen citrates, silver iodines, silver oxides, silver zirconium phosphates, silver glass, and combinations thereof.

**[00101]** Particular embodiments of antimicrobial agents can be the following: (1) "AglON": A silver-containing inorganic zeolite food-grade antimicrobial agent, type AJ, which contains 2.5% silver, and which is commercially available under the trade designation "AglON" Antimicrobial from AglON Technologies, Inc., Wakefield, Mass; (2) "Alphasan": A silver zirconium phosphate, commercially available under the trade designation "ALPHASAN RC 5000" from Milliken Chemicals, Spartanburg, S.C.; (3) "Silver glass": A silver glass antimicrobial agent, commercially available from Giltech, Scotland, UK.; (4) "Copper glass": A copper glass antimicrobial agent, commercially available from Giltech, Scotland, UK; (5) "Silver nanoparticles": A 20% silver nanoparticle

dispersion in isopropanol, commercially available under the trade designation "SILVERJET DGP-(I)-20" from Advanced Nano Particles (ANP), Seoul, South Korea; (6) "Silver oxide": Silver oxide (AgO) having a formula weight of 123.9, commercially available from Alfa Aesar, Ward Hill, Mass.; (7) "Ammonium Carbonate": Ammonium carbonate salt, commercially available from Aldrich, Milwaukee, Wis.; (8) "Triclosan": Triclosan antimicrobial agent, commercially available from Ciba Specialty Chemicals., Tarrytown, N.Y.; (9) "DMAEMA-CCI": Dimethylhexadecylammoniummethacrylate-CCI antimicrobial agent, commercially available from Ciba Specialty Chemicals, Tarrytown, N.Y.; (10) "Cosmocil CQ": An antimicrobial agent commercially available under the trade designation "COSMOCIL CQ" from Avecia, Inc., Wilmington Del.; (11) "Vantocil P": A poly(iminoimidocarbonylimidocarbonyliminohexamethylene hydrochloride), commercially available under the trade designation "VANTOCIL P" from Arch Chemicals, Inc., Norwalk, Conn.; (12) "Myacide AS Plus": An antimicrobial agent commercially available under the trade designation "MYACIDE AS PLUS" from BASF Corp., Parsippany, N.J.; (13) "CHG": 20% chlorhexidine gluconate by weight in water, commercially available from Xttrium Laboratories, Inc., Chicago, Ill.; (14) "Bardac 205M": A quaternary ammonium compound commercially available under the trade designation "BARDAC 205M" from Lonza Group Ltd., Valais, Switzerland; (15) "Bardac 208M": A quaternary ammonium compound commercially available under the trade designation "BARDAC 208M" from Lonza Group Ltd., Valais, Switzerland; (16) "3M 906 Hardcoat": A polymerizable precursor commercially available under the trade designation "3M 906" Abrasion Resistant Hardcoat, from 3M Corporation, St. Paul, Minn.; (17) "3M SG composition": A polymerizable precursor commercially available under the trade designation "SCOTCHGARD" UV-curable film protector composition, from 3M Corporation, St. Paul, Minn.; (18) "UVHC3000": A polymerizable precursor commercially available under the trade designation "UVHC3000", from GE Silicones, Waterford, N.Y.; (19) "3M UV-Formulation": A polymerizable precursor containing 13.84 parts of an aliphatic urethane diacrylate diluted with 12% hexanediol diacrylate (commercially available under the trade designation "EBECRYL 284" from UCB Chemicals, Smyrna, Ga.), 24.24 parts of iso-

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octyleacrylate (available from Sartomer Co., Exton, Pa.), 13.84 parts etrahydrofurfurylacrylate (also available from Sartomer Co.), 5 parts benzophenone free radical-generating photoinitiator (also available from Sartomer Co.), and 5 parts isopropylthioxanthone photoinitiator synergist (available from Aceto Corp., New Hyde Park, N.Y.); (20) "Irgacure 819": A phosphine oxide, phenyl bis(2,4,6-trimethyl benzoyl)) photoinitiator, commercially available under the trade designation "IRGACURE 819", from Ciba Specialty Chemicals, Tarrytown, N.Y.; (21) "Lauricidin": A glycerol monolaurate fatty acid monoester, commercially available under the trade designation "LAURICIDIN" from Med-Chem Laboratories, East Lansing, Mich. [0091]"DOSS surfactant": A dioctylsulfosuccinate (DOSS) surfactant, commercially available from Alfa Aesar, Ward Hill, Mass.; (22) "Salicylic acid": A 2-hydroxybenzoic acid ( $\text{HOC}_6\text{H}_4\text{CO}_2\text{H}$ ) with a formula weight of 138.1, commercially available from Sigma-Aldrich Chemical Company, Saint Louis, Mo; (23) "Select Silver" antimicrobial agents commercially available from Milliken Chemical Company, Spartanburg, SC; (24) "Hygentic" antimicrobial additives commercially available from BASF Corporation, Tarrytown, NY; or (25) Agion SL antimicrobial additive Wakefield, MA.

**[00102]** In one embodiment, the antimicrobial agent can be chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof. In one embodiment, the antimicrobial agent or additive is a silver oxide. In one embodiment, the antimicrobial agent or additive can be silver magnesium silica, optionally having an average particle size of around 40 microns, although similar additive types with differing particle sizes can be used. The glass transition temperature ( $T_g$ ) of the polyesters useful in the invention, if measured, was determined using a TA DSC 2920 from Thermal Analyst Instrument at a scan rate of  $20^\circ\text{C}/\text{min}$ . Polymer A can have a  $T_g$  of  $90$  to  $150^\circ\text{C}$ ,  $90$  to  $140^\circ\text{C}$ , or  $90$  to  $130^\circ\text{C}$ , or  $90$  to  $120^\circ\text{C}$ , or  $100$  to  $140^\circ\text{C}$ , or  $100$  to  $130^\circ\text{C}$ , or  $100$  to  $120^\circ\text{C}$ .

**[00103]** In one embodiment, certain polyesters useful in this invention can be visually clear. The term "visually clear" is defined herein as a low amount of cloudiness, haziness, and/or muddiness, when inspected visually.

**[00104]** In one embodiment, the molded samples of blends of the invention can be measured for optical (color and haze) using a Hunterlab Ultrascan Vis having a 10° observer in transmission mode. Color and haze can be measured using the following configuration: Transmittance Mode, D65 Light Source (Daylight, Noon World Average, 6500 °K color temperature), 10° standard observer, large area view (1" diameter), and specular included.

**[00105]** In another embodiment, molded samples of blends of the invention can be measured for optical (color and haze) using ASTM D 1003. In one embodiment, these measurements can be performed on 1/8 inch width samples. In another embodiment, these measurements are performed on 1/8 inch width samples.

**[00106]** 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). In one embodiment, the refractive index of the polymer blend of Polymers A and B can be 1.48 to 1.58. In one embodiment, the refractive index of the polymer blend of Polymers A and B can be 1.50 to 1.55. In one embodiment, the refractive index of the polymer blend of Polymers A and B can be 1.50 to 1.56. In one embodiment, the refractive index of the polymer blend of Polymers A and B can be 1.52 to 1.55. In one embodiment, the refractive index of the antimicrobial additive can be 1.48 to 1.58. In one embodiment, the difference in refractive index between the blend of Polymers A and B and the antimicrobial additive can also be between about 0.04 to about -0.04, or about 0.02 to about -0.02.

**[00107]** 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). 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 D1003 and/or 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 described herein. Again in one embodiment, these measurements can be performed on 1/8 inch width samples. In another embodiment, these measurements are performed on 1/8 inch width samples.

**[00108]** In one aspect of the invention, each embodiment of the invention can have haze values of from 0 to 65, or 0 to 60, or 0 to 55, or 0 to 50, or 0 to 45, or 0 to 40, or 0 to 35, or 0 to 20, or 0 to 15, or 1 to 20, or 1 to 15, or 5 to 20, or 5 to 15, or 10 to 20, or 10 to 16, or 10 to 15 percent as determined by ASTM Method D1003 or by any other method described herein. While these haze values can be present at any percent loading, in one embodiment, the polymer blends of the invention can have a haze value of less than 50 % at up to 8 % by weight of at least one antimicrobial agent or antimicrobial additive wherein the haze value is determined by ASTM Method D1003 or by other methods described herein and where the weight percentage of the antimicrobial agent is based on the total weight of the polymer blend.

**[00109]** In one embodiment, the polyesters useful in the invention and/or the polyester compositions of the invention, [in one embodiment, in the presence of and/or in the absence of toner(s)], can have color values  $L^*$ ,  $a^*$  and  $b^*$  which can be determined using a Hunter Lab Ultrascan Spectra Colorimeter manufactured by Hunter Associates Lab Inc., Reston, Va. The color determinations are averages of values measured on either pellets of the polyesters or plaques or other items injection molded or extruded from them. They are determined by the  $L^*a^*b^*$  color system of the CIE (International Commission on Illumination) (translated), wherein  $L^*$  represents the lightness coordinate,  $a^*$  represents the red/green coordinate, and  $b^*$  represents the yellow/blue coordinate. In certain embodiments, the  $b^*$  values for the polyesters useful in the invention [in one embodiment, in the presence of and/or in the absence of toner(s)] can be from -

12 to less than 12 and the  $L^*$  values can be from 50 to 90. In other embodiments, the  $b^*$  values for the polyesters useful in the invention [in one embodiment, in the presence of and/or in the absence of toner(s)] can be present in one of the following ranges: from -10 to 10; -10 to less than 10; -10 to 9; -10 to 8; -10 to 7; -10 to 6; -10 to 5; -10 to 4; -10 to 3; -10 to 2; from -5 to 9; -5 to 8; -5 to 7; -5 to 6; -5 to 5; -5 to 4; -5 to 3; -5 to 2; 0 to 9; 0 to 8; 0 to 7; 0 to 6; 0 to 5; 0 to 4; 0 to 3; 0 to 2; 1 to 10; 1 to 9; 1 to 8; 1 to 7; 1 to 6; 1 to 5; 1 to 4; 1 to 3; and 1 to 2. In other embodiments, the  $L^*$  value for the polyesters useful in the invention can be present in one of the following ranges: 50 to 60; 50 to 70; 50 to 80; 50 to 90; 60 to 70; 60 to 80; 60 to 90; 70 to 80; 79 to 90.

**[00110]** Notched Izod impact strength, as described in ASTM D256, is a common method of measuring toughness. Notched Izod impact strength is measured herein at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256. In one embodiment, certain polyesters useful in the invention can exhibit a notched Izod impact strength of at least 1/2 ft-lb/in at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256. In one embodiment, certain polyesters useful in the invention can exhibit a notched Izod impact strength of at least 1 ft-lb/in at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256. In one embodiment, certain polyesters useful in the invention can exhibit a notched Izod impact strength of at least 2 ft-lb/in at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256. In one embodiment, certain polyesters useful in the invention can exhibit a notched Izod impact strength of at least 3 ft-lb/in at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256. In one embodiment, certain polyesters useful in the invention can exhibit a notched Izod impact strength of at least 4 ft-lb/in at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256. In one embodiment, certain polyesters useful in the invention can exhibit a notched Izod impact strength of at least 5 ft-lb/in at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256. In another embodiment, certain polyesters useful in the invention can exhibit a notched Izod impact strength of at least 7.5



ft-lb/in at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256. In one embodiment, certain polyesters useful in the invention can exhibit a notched Izod impact strength of at least 10 ft-lb/in at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256.

**[00111]** Certain polyester(s) and/or polyester compositions of the invention have improved environmental stress cracking resistance. Generally, environmental stress cracking resistance testing according to the present invention is described in R. L. Bergen, Jr., SPE J. 667-670 (1962) entitled "Stress cracking of rigid thermoplastics". Certain polyester(s) and/or polyester compositions of the invention can have a lipid critical strain of at least 0.6 % or at least 0.7% or at least 0.8 % or at least 0.9 % or of greater than 0.9 %. Certain polyester(s) and/or polyester compositions of the invention can have an isopropanol critical strain of at least 0.9 % or at least 1.0 % or of greater than 1.0 %. Certain polyester(s) and/or polyester compositions of the invention can have a lipid critical strain of at least 0.9 % and an isopropanol critical strain of greater than 1.0 %. Lipid critical strain and/or isopropanol critical strain are measured as demonstrated by the Examples of the present invention and can be measured as described in R. L. Bergen, Jr., SPE J. 667-670 (1962) entitled "Stress cracking of rigid thermoplastics".

**[00112]** In one embodiment, phosphorus compound(s) can be useful in the invention and can be an organic compound such as, for example, a phosphorus acid ester containing halogenated or non-halogenated organic substituents. The phosphorus compound(s) useful in the invention can comprise a wide range of phosphorus compounds well-known in the art such as, for example, phosphines, phosphites, phosphinites, phosphonites, phosphinates, phosphonates, phosphine oxides, and phosphates.

**[00113]** In one embodiment, the phosphorus compounds useful in the invention include but are not limited to alkyl, aryl or mixed alkyl aryl esters or partial esters of phosphoric acid, phosphorus acid, phosphinic acid, phosphonic acid, or phosphonous acid. The alkyl or aryl groups can contain one or more substituents.

**[00114]** The esters can contain alkyl, branched alkyl, substituted alkyl, alkyl ethers, aryl, and/or substituted aryl groups. The esters can also have at least one alkyl group and at least one aryl group. The number of ester groups present in the particular phosphorus compound can vary from zero up to the maximum allowable based on the number of hydroxyl groups present on the phosphorus compound used. For example, an alkyl phosphate ester can include one or more of the mono-, di-, and tri alkyl phosphate esters; an aryl phosphate ester includes one or more of the mono-, di-, and tri aryl phosphate esters; and an alkyl phosphate ester and/or an aryl phosphate ester also include, but are not limited to, mixed alkyl aryl phosphate esters having at least one alkyl and one aryl group.

**[00115]** In one aspect, the phosphorus compounds useful in the invention can comprise at least one phosphorus compound chosen from at least one of substituted or unsubstituted alkyl phosphate esters, substituted or unsubstituted aryl phosphate esters, substituted or unsubstituted mixed alkyl aryl phosphate esters, diphosphites, salts of phosphoric acid, phosphine oxides, and mixed aryl alkyl phosphites, reaction products thereof, and mixtures thereof. The phosphate esters include esters in which the phosphoric acid is fully esterified or only partially esterified.

**[00116]** Catalysts useful in making the polyesters useful in the invention can include, but are not limited to, those based on gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, tin, titanium, aluminum compounds, and an aluminum compound with lithium hydroxide or sodium hydroxide. In one embodiment, the catalyst can be a combination of at least one tin compound and at least one titanium compound. In one embodiment, the catalyst can be at least one tin compound. In another embodiment, the catalyst can be at least one titanium compound.

**[00117]** In one embodiment, catalyst amounts can range from 10 ppm to 20,000 ppm or 10 to 10,000 ppm, or 10 to 5000 ppm or 10 to 1000 ppm or 10 to 500 ppm, or 10 to 300 ppm or 10 to 250 ppm based on the catalyst metal and based on the weight of the final polymer. The process can be carried out in either

a batch or continuous process. In one embodiment, the process is carried out in a continuous process.

**[00118]** In one embodiment, the polymers useful in the invention can be prepared by a process comprising the steps of:

- (A) heating a mixture comprising the monomers useful in the polyesters useful in the invention in the presence of at least one tin catalyst at a temperature of 150 to 250°C for a time sufficient to produce an initial polyester;
- (B) polycondensing the product of Step (A) by heating it at a temperature of 230 to 320°C for 1 to 12 hours; and
- (C) removing any unreacted glycols.

**[00119]** Reaction times for the esterification Step (A) are dependent upon the selected temperatures, pressures, and feed mole ratios of glycol to dicarboxylic acid.

**[00120]** Typically, Step (B) and Step (C) can be conducted at the same time. These steps can be carried out by methods known in the art such as by placing the reaction mixture under a pressure ranging, from 0.002 psig to below atmospheric pressure, or by blowing hot nitrogen gas over the mixture.

**[00121]** The polyesters of the present invention can also be prepared by any other procedures known to persons skilled in the art. 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. Stirring or appropriate conditions are used in both stages to ensure adequate heat transfer and surface renewal of the reaction mixture.

**[00122]** The invention further relates to a polymer blend optionally containing an additional polymeric component. The blend can comprise:

- (a) from 1 to 99 weight % of polymer A;
- (b) from 1 to 99 weight % of polymer B; and

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(c) up to 98 weight % of at least one additional polymeric components;  
and (d) 0.01 to 20 % by weight; said weight percentages being based on the total weight of the polymer blend..

**[00123]** Suitable examples of the additional polymeric components include, but are not limited to, nylon; polyesters different than polymer A and polymer B; polyamides such as ZYTEL® from DuPont; polystyrene; polystyrene copolymers; styrene acrylonitrile copolymers; acrylonitrile butadiene styrene copolymers; poly(methylmethacrylate); acrylic copolymers; poly(ether-imides) such as ULTEM® (a poly(ether-imide) from General Electric); polyphenylene oxides such as poly(2,6-dimethylphenylene oxide) or poly(phenylene oxide)/polystyrene blends such as NORYL 1000® (a blend of poly(2,6-dimethylphenylene oxide) and polystyrene resins from General Electric); polyphenylene sulfides; polyphenylene sulfide/sulfones; poly(ester-carbonates); polycarbonates such as LEXAN® (a polycarbonate from General Electric); polysulfones; polysulfone ethers; and poly(ether-ketones) of aromatic dihydroxy compounds; or mixtures of any of the foregoing polymers.

**[00124]** In addition, the polymer blends of the invention may also contain common additives such as colorants, toner(s), dyes, mold release agents, flame retardants, plasticizers, nucleating agents, stabilizers, and antioxidants, including but not limited to, UV stabilizers, thermal stabilizers other than the phosphorus compounds describe herein, and/or reaction products thereof, fillers, and impact modifiers. In one embodiment, the polymer blends can contain from 0.01 to 25 % by weight of one or more of these additives. Examples of typical commercially available impact modifiers well known in the art and useful in this invention include, but are not limited to, ethylene/propylene terpolymers, functionalized polyolefins such as those containing methyl acrylate and/or glycidyl methacrylate, styrene-based block copolymeric impact modifiers, and various acrylic core/shell type impact modifiers. Residues of such additives are also contemplated as part of the polyester composition.

**[00125]** In addition, certain agents which colorize the polymer can be added to the melt. In one embodiment, a bluing toner is added to the melt in order to reduce the b\* of the resulting polyester polymer melt phase product. Such bluing

agents include blue inorganic and organic toner(s). In addition, red toner(s) can also be used to adjust the  $a^*$  color. Organic toner(s), e.g., blue and red organic toner(s), such as those toner(s) described in U.S. Pat. Nos. 5,372,864 and 5,384,377, which are incorporated by reference in their entirety, can be used. The organic toner(s) can be fed as a premix composition. The premix composition may be a neat blend of the red and blue compounds or the composition may be pre-dissolved or slurried in one of the polyester's raw materials, e.g., ethylene glycol.

**[00126]** The total amount of toner components added depends, of course, on the amount of inherent yellow color in the base polyester and the efficacy of the toner. Generally, in one embodiment, a concentration of up to about 15 ppm of combined organic toner components and a minimum concentration of about 0.5 ppm can be used. The total amount of bluing additive typically ranges from 0.5 to 10 ppm.

**[00127]** The toner(s) can be added to the esterification zone or to the polycondensation zone. Preferably, the toner(s) are added to the esterification zone or to the early stages of the polycondensation zone, such as to a prepolymerization reactor

**[00128]** The aliphatic polyester composition of the invention also can comprise at least one hindered amine light stabilizer, abbreviated herein as "HALS". Many of the HALS useful in the present invention are known compounds and some are commercially available. The HALS can include their salts, N-oxides and N-hydroxides. In general, the HALS can be described as having an amino nitrogen contained in a carbon-nitrogen-carbon chain which forms part of a non-aromatic heterocyclic ring where each of the two carbon atoms of the chain is bonded to two lower alkyl groups which may be the same or different, each lower alkyl group containing from 1 to 22 carbon atoms, or to an alicyclic group containing from 3 to 8 carbon atoms, which sterically hinder the amine. For example, in one embodiment of the invention, the HALS can comprise 2,2,6,6-tetraalkylpiperidines, their acid addition salts or complexes with metal compounds.

**[00129]** Ultraviolet light absorbers (UVAs) can also be included in the polyester compositions of the invention. In one embodiment, the term "ultraviolet light absorber" is defined as one compound or a mixture of compounds that absorb light in the range of 290-400 nm with a minimal absorbance between 400 and 700 nm, and that improves the weatherability of the polymer compositions. In accordance with the present invention, the aliphatic polyesters of the present invention can have blended therein at least one UVA selected from triazines, cyanoacrylates, benzotriazoles, naphthalenes, and benzoxazinones and mixtures thereof. Such materials are described in greater detail in US Pat. Nos. 6,352,783, 5,480,926 and 5,783,307, and United States Publication 2006/0111481 published on May 25, 2006.

**[00130]** Within the scope of this invention are commercially available UVAs such as, for example: Cyasorb UV-2337 (Cytec Industries, CAS# 25973-55-1), Cyasorb UV-5411 (Cytec Industries, CAS# 3147-75-9), Cyasorb UV-5365 (Cytec Industries, CAS# 2440-22-4), Cyasorb UV-1164 (Cytec Industries, CAS# 2725-22-6), Cyasorb UV-3638 (Cytec Industries, CAS# 18600-59-4), Tinuvin 213 (Ciba Specialty Chemicals, CAS# 104810-47-1), Tinuvin 234 (Ciba Specialty Chemicals, CAS# 70321-86-7), Tinuvin 320 (Ciba Specialty Chemicals, CAS# 3846-71-7), Tinuvin 326 (Ciba Specialty Chemicals, CAS# 3896-11-5), Tinuvin 327 (Ciba Specialty Chemicals, CAS# 3864-99-1), Tinuvin 328 (Ciba Specialty Chemicals, CAS# 25973-55-1), Tinuvin 329 (Ciba Specialty Chemicals, CAS# 3147-75-9), Tinuvin 350 (Ciba Specialty Chemicals, CAS# 36437-37-3), Tinuvin 360 (Ciba Specialty Chemicals, CAS# 103597-45-1), Tinuvin 571 (Ciba Specialty Chemicals, CAS# 23328-53-2) and Tinuvin 1577 (Ciba Specialty Chemicals, CAS# 147315-50-2). In one embodiment, the UVAs are chosen from benzotriazoles, triazines and benzoxazin-4-ones such as Cyasorb UV-1164 (Cytec Industries, CAS# 2725-22-6), Cyasorb UV-3638 (Cytec Industries, CAS# 18600-59-4), Tinuvin 1577 (Ciba Specialty Chemicals, CAS# 147315-50-2), Tinuvin 234 (Ciba Specialty Chemicals, CAS# 70321-86-7) and Tinuvin 328 (Ciba Specialty Chemicals, CAS# 25973-55-1). In another embodiment, the UVAs are chosen from Cyasorb UV-1164 (Cytec Industries, CAS# 2725-22-6), Cyasorb UV-3638 (Cytec Industries, CAS# 18600-59-4) and Tinuvin 1577 (Ciba Specialty

Chemicals, CAS# 147315-50-2. A combination of two or more of any of the UVAs may be used within the scope of this invention.

**[00131]** The polymer blends of the present invention can contain one or more compounds chosen from phenolic antioxidants, hindered phenols, phosphite stabilizers, phosphonite stabilizers and other stabilizers known to one skilled in the art.

**[00132]** The terms "phenolic antioxidants" and "hindered phenol" are primary antioxidants that are known to those skilled in the art and may be represented by the structures listed on pages 98-108 in the Plastic Additives Handbook 5<sup>th</sup> Edition (Hanser Gardner Publications, Inc., Cincinnati, OH, USA, 2001), incorporated herein by reference in its entirety. Some common phenolic antioxidants are as follows: Irganox 1010 (Ciba Specialty Chemicals, CAS# 6683-19-8), Irganox 1330 (Ciba Specialty Chemicals, CAS# 1709-70-2) and Irganox 3114 (Ciba Specialty Chemicals, CAS# 27676-62-6).

**[00133]** The terms "phosphite stabilizers" and "phosphonite stabilizers" refer to secondary antioxidants that are known to those skilled in the art and may be represented by the structures listed on pages 109-112 in the Plastic Additives Handbook 5<sup>th</sup> Edition (Hanser Gardner Publications, Inc., Cincinnati, OH, USA, 2001), incorporated herein by reference in its entirety. Some common phosphite stabilizers are as follows: Ultrinox 626 (GE Specialty Chemicals, CAS# 26741-53-7), Irgafos 168 (Ciba Specialty Chemicals, CAS# 31570-04-4), Weston 619 (GE Specialty Chemicals, CAS# 3806-34-6) and Doverphos S-9228 (Dover Chemicals, CAS# 154862-43-8).

**[00134]** For example, in one embodiment of the invention, alkyl phosphites (for example Weston 619) may be combined with an ultraviolet light absorber. For example, in one embodiment of the invention, aryl phosphites (for example, Irgafos 168) can be combined with a hindered amine light stabilizer and optionally, an ultraviolet light absorber. For example, in one embodiment, phenolic antioxidants (for example, Irganox 1010) can be added during melt processing. Phenolic antioxidants are particularly useful when a polyglycol ether [for example, poly(tetramethylene glycol)] is present.

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**[00135]** The various components of the copolyester compositions such as, for example, the flame retardant, release additive, other processing aids, and toners, may be blended in batch, semicontinuous, or continuous processes.

**[00136]** Commercial applications of interest to this technology include but are not limited to medical devices such as luers, tubing, intravenous components, needle-free valves, connectors, and various other devices where clarity of parts is desired. In addition, medical packaging and food packaging are other areas where the technology has applicability.

**[00137]** The technology can also be used in applications including but not limited to blender housings, sports bottles, water bottles, 5 gallon water containers, ice machine parts, and/or other parts where both clarity and antimicrobial additives are desired.

**[00138]** This invention can be further illustrated by the following examples of preferred embodiments thereof, although it will be understood that these examples are included merely for purposes of illustration and are not intended to limit the scope of the invention unless otherwise specifically indicated.



## **EXAMPLES**

### **Sample Preparation**

**[00139]** Samples were prepared by blending (1) a aliphatic-aromatic copolyester with a aliphatic copolyester, and (2) by blending a aliphatic-aromatic copolyester with an antimicrobial additive, and (3) by blending a aliphatic-aromatic copolyester with a aliphatic copolyester with an antimicrobial additive. The additive used for this work is a silver magnesium silica complex (SR12). This particular additive is sold by Milliken Chemical Company as Select Silver® SR12 antimicrobial agent. The polymers used for this study are aromatic-aliphatic polymer 1 (AAP1) and aromatic-aliphatic polymer 2 (AAP2). AAP2 is a copolyester having 100 mole percent terephthalic acid residues, 78 mole percent 1,4-cyclohexanedimethanol residues, and 22 mole percent 2,2,4,4,-tetramethyl-1,3-cyclobutanediol residues and the polymer has a specific gravity of 1.18. AAP1 is a copolyester having 100 mole percent terephthalic acid residues, 65 mole percent 1,4-cyclohexanedimethanol residues, and 35 mole percent 2,2,4,4,-tetramethyl-1,3-cyclobutanediol residues and the polymer has specific gravity of 1.17. The aliphatic polyester (AP1) is based on 100 mole percent 1,4-cyclohexanedicarboxylic acid residues and 100 mole percent 1,4-cyclohexanedimethanol residues. The experimental design can be seen in Table 1.

Table 1

Example	Aromatic-Aliphatic Polyester Type	Aromatic-Aliphatic Polyester (wt %)	AP1 (wt %)	SR 12 (wt %)
CE #1	AAP1	100%	0%	0%
CE #2	AAP1	90%	10%	0%
CE #3	AAP1	83%	17%	0%
CE #4	AAP1	76%	24%	0%
CE #5	AAP1	98%	0%	2%
EX #1	AAP1	88%	10%	2%
EX #2	AAP1	81%	17%	2%
EX #3	AAP1	74%	24%	2%
CE #6	AAP2	100%	0%	0%
CE #7	AAP2	80%	20%	0%
CE #8	AAP2	75%	25%	0%
CE #9	AAP2	70%	30%	0%
CE #10	AAP2	98%	0%	2%
EX #4	AAP2	78%	20%	2%
EX #5	AAP2	73%	25%	2%
EX #6	AAP2	68%	30%	2%

## Compounding

**[00140]** The materials were dried separately with the aliphatic-aromatic polyester being dried at 85 degree celsius for 8 hours in a desiccant drying system and the aliphatic polyester was dried at 65 degree celsius for 8 hrs in a desiccant drying system. The antimicrobial additive was used without additional drying. The aliphatic-aromatic copolyester was cooled to 65C prior to hand blending with the aliphatic polyester and the antimicrobial additive. Blended samples were compounded on a 30 mm Werner Pfleiderer co-rotating twin screw extruder. A "medium shear" screw configuration was used. The barrel zone temperatures were set 260 degrees celsius except for Zone 1A and Zone 1B which were set at 180 and 200 degrees celsius respectively. The feed zone was cooled with circulating water and the die that was set at 260 degrees celsius. The screw speed was 350 rpm and torque outputs on the machine ranged between

70 and 100 percent. All materials were fed at barrel zone 1 of the twin screw. The extrudate from the twin screw was forced through a pelletizing rod type forming a strand that was cooled by a water bath. The first 5 minutes of extrudate was not collected in order to ensure the extruder had been adequately purged.. Samples were collected after the strands were quenched in a water bath prior to being chopped into pellets using a Conair pelletizing cutter.

### ***Injection Molding***

**[00141]** The compounded samples were dried at 80°C for 8 hrs in a desiccant drying system. After drying, the materials were injection molded into tensile bars, flex bars, and plaques. For comparative examples (1-10) and examples (1-6), the plaques specimens are 101mm long by 101mm wide by 3.2mm thick. The materials were molded on a Toyo 90 molding machine. The Toyo 90 was set at 280 degrees celsius on all zones. For comparative examples 1-5 and examples 1-3, the mold temperature was set at 60 degrees Celsius. For comparative examples 6-10 and examples 4-6, the mold temperature was set at 43 degrees celsius. The materials had an overall cycle time between 35 and 40 seconds.

**[00142]** The molded samples were then measured for optical (color and haze) using a Hunterlab Ultrascan Vis having a 10° observer in transmission mode. Color and haze were measured using the following configuration: Transmittance Mode, D65 Light Source (Daylight, Noon World Average, 6500 °K color temperature), 10° standard observer, large area view (1" diameter), and specular included. The haze data is reported in Table 2 and the color data is reported in Table 3.

### **Comparative Example 1:**

**[00143]** 100 weight percent of AAP1 was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab

Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Comparative Example 2:**

**[00144]** 90 weight percent of AAP1 was blended with 10 weight percent AP1. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Comparative Example 3:**

**[00145]** 83 weight percent of AAP1 was blended with 17 weight percent AP1. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Comparative Example 4:**

**[00146]** 76 weight percent of AAP1 was blended with 17 weight percent AP1. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Comparative Example 5:**

**[00147]** 98 weight percent of AAP1 was blended with 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Example 1:**

**[00148]** 88 weight percent of AAP1 was blended with 10 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Example 2:**

**[00149]** 81 weight percent of AAP1 was blended with 17 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Example 3:**

**[00150]** 74 weight percent of AAP1 was blended with 24 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Comparative Example 6:**

**[00151]** 100 weight percent of AAP2 was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab

Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Comparative Example 7:**

**[00152]** 80 weight percent of AAP2 was blended with 20 weight percent AP1. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Comparative Example 8:**

**[00153]** 75 weight percent of AAP2 was blended with 25 weight percent AP1. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Comparative Example 9:**

**[00154]** 70 weight percent of AAP2 was blended with 30 weight percent AP1. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Comparative Example 10:**

**[00155]** 98 weight percent of AAP2 was blended with 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Example 4:**

**[00156]** 78 weight percent of AAP2 was blended with 20 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Example 5:**

**[00157]** 73 weight percent of AAP2 was blended with 25 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

**Example 6:**

**[00158]** 68 weight percent of AAP2 was blended with 30 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 3.2mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 2 and Table 3.

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TABLE 2

Example	Aromatic-Aliphatic Polyester Type	Aromatic-Aliphatic Polyester (wt %)	AP1 (wt %)	SR12 (wt %)	Haze % D65/10	Y Total D65/10	Y Diffuse D65/10
CE #1	AAP1	100%	<b>0%</b>	0%	2.1	88.1	1.8
CE #2	AAP1	90%	<b>10%</b>	0%	0.9	89.4	0.8
CE #3	AAP1	83%	<b>17%</b>	0%	1.2	89.2	1.0
CE #4	AAP1	76%	<b>24%</b>	0%	1.1	89.1	1.0
CE #5	AAP1	98%	<b>0%</b>	2%	25.7	79.0	20.3
EX #1	AAP1	88%	<b>10%</b>	2%	15.1	81.2	12.3
EX #2	AAP1	81%	<b>17%</b>	2%	11.6	84.0	9.8
EX #3	AAP1	74%	<b>24%</b>	2%	10.2	84.5	8.6
CE #6	AAP2	100%	<b>0%</b>	0%	2.0	87.7	1.7
CE #7	AAP2	80%	<b>20%</b>	0%	1.5	88.7	1.3
CE #8	AAP2	75%	<b>25%</b>	0%	1.8	88.7	1.6
CE #9	AAP2	70%	<b>30%</b>	0%	1.5	87.5	1.3
CE #10	AAP2	98%	<b>0%</b>	2%	39.0	81.4	31.7
EX #4	AAP2	78%	<b>20%</b>	2%	14.4	83.8	12.0
EX #5	AAP2	73%	<b>25%</b>	2%	10.6	84.2	8.9
EX #6	AAP2	68%	<b>30%</b>	2%	9.8	84.4	8.3



TABLE 3

Example	Aromatic-Aliphatic Polyester Type	Aromatic-Aliphatic Polyester (wt %)	AP1 (wt %)	SR 12 (wt %)	L*	a*	b*
CE #1	AAP1	100%	0%	0%	95.2	-0.7	2.8
CE #2	AAP1	90%	10%	0%	95.7	-0.4	1.7
CE #3	AAP1	83%	17%	0%	95.7	-0.4	1.6
CE #4	AAP1	76%	24%	0%	95.6	-0.5	2.1
CE #5	AAP1	98%	0%	2%	91.2	-0.3	4.1
EX #1	AAP1	88%	10%	2%	92.2	-0.4	3.8
EX #2	AAP1	81%	17%	2%	93.5	-0.8	3.9
EX #3	AAP1	74%	24%	2%	93.7	-0.8	3.4
CE #6	AAP2	100%	0%	0%	95.0	-0.7	2.7
CE #7	AAP2	80%	20%	0%	95.4	-0.4	1.8
CE #8	AAP2	75%	25%	0%	95.5	-0.4	1.9
CE #9	AAP2	70%	30%	0%	95.0	-0.4	2.0
CE #10	AAP2	98%	0%	2%	92.3	-0.4	3.5
EX #4	AAP2	78%	20%	2%	93.3	-0.6	3.7
EX #5	AAP2	73%	25%	2%	93.6	-0.7	3.5
EX #6	AAP2	68%	30%	2%	93.6	-0.8	3.2

### ***Injection Molding – The Effect of Thickness***

**[00159]** The compounded samples were dried at 80°C, for 8 hrs in a desiccant drying system. After drying, the materials were injection molded into plaques. The plaques specimens are 101mm long by 101mm wide by 2.4mm thick for comparative examples (11, 13), examples (7-9) and examples (13-15). The plaque specimens are 101mm long by 101mm wide by 1.6mm thick for comparative examples (12,14) and examples (10-12) and examples (16-18).

**[00160]** The materials were molded on a Toyo 90 molding machine. The Toyo 90 was set at 280 degrees celsius on all barrel zones and the materials were injected into a mold set at 60 degrees celsius. The materials had an overall cycle time between 35 and 40 seconds.

**[00161]** The molded samples were then measured for optical (color and haze) using a Hunterlab Ultrascan Vis having a 10° observer in transmission mode. Color and haze were measured using the following configuration: Transmittance Mode, D65 Light Source (Daylight, Noon World Average, 6500 °K color temperature), 10° standard observer, large area view (1" diameter), and specular included. The haze data and b\* color data is reported in Table 4.

**Comparative Example 11:**

**[00162]** 98 weight percent of AAP1 was blended with 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 2.4mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 7:**

**[00163]** 88 weight percent of AAP1 was blended with 10 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 2.4mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 8:**

**[00164]** 81 weight percent of AAP1 was blended with 17 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 2.4mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 9:**

**[00165]** 74 weight percent of AAP1 was blended with 24 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 2.4mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Comparative Example 12:**

**[00166]** 98 weight percent of AAP1 was blended with 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 1.6mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 10:**

**[00167]** 88 weight percent of AAP1 was blended with 10 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 1.6mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 11:**

**[00168]** 81 weight percent of AAP1 was blended with 17 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 1.6mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 12:**

**[00169]** 74 weight percent of AAP1 was blended with 24 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 1.6mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Comparative Example 13:**

**[00170]** 98 weight percent of AAP2 was blended with 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 2.4mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 13:**

**[00171]** 78 weight percent of AAP2 was blended with 20 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 2.4mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 14:**

**[00172]** 73 weight percent of AAP2 was blended with 25 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 2.4mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 15:**

**[00173]** 68 weight percent of AAP2 was blended with 30 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 2.4mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Comparative Example 14:**

**[00174]** 98 weight percent of AAP2 was blended with 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 1.6mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 16:**

**[00175]** 78 weight percent of AAP2 was blended with 20 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 1.6mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 17:**

**[00176]** 73 weight percent of AAP2 was blended with 25 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 1.6mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

**Example 18:**

**[00177]** 68 weight percent of AAP2 was blended with 30 weight percent AP1 and 2 weight percent of an antimicrobial additive based on a silver magnesium silica complex. The blend was pelletized on a Werner Pfleiderer twin screw extruder and then molded into 101mm \* 101mm \* 1.6mm plaques on a Toyo 90 molding machine. The plaques were measured on a Hunterlab Ultrascan Vis to determine color and haze. The data can be observed in Table 4.

TABLE 4

<b>Example</b>	<b>Aromatic-Aliphatic Polyester Type</b>	<b>Aromatic-Aliphatic Polyester (wt %)</b>	<b>AP1 (wt %)</b>	<b>SR 12 (wt %)</b>	<b>Thickness (mm)</b>	<b>b*</b>	<b>haze (%)</b>
CE #11	AAP1	98%	0%	2%	2.4	4.476	24.07
EX #7	AAP1	88%	10%	2%	2.4	3.271	13.75
EX #8	AAP1	81%	17%	2%	2.4	3.257	10.21
EX #9	AAP1	74%	24%	2%	2.4	3.054	8.69
CE #12	AAP1	98%	0%	2%	1.6	3.217	16.94
EX #10	AAP1	88%	10%	2%	1.6	2.596	10.72
EX #11	AAP1	81%	17%	2%	1.6	2.488	8.18
EX #12	AAP1	74%	24%	2%	1.6	2.099	6.85
CE #13	AAP2	98%	0%	2%	2.4	3.039	35.32
EX #13	AAP2	78%	20%	2%	2.4	3.629	17.04
EX #14	AAP2	73%	25%	2%	2.4	3.209	8.82
EX #15	AAP2	68%	30%	2%	2.4	2.738	7.7
CE #14	AAP2	98%	0%	2%	1.6	2.514	25.76
EX #16	AAP2	78%	20%	2%	1.6	2.427	9.21
EX #17	AAP2	73%	25%	2%	1.6	2.355	6.85
EX #18	AAP2	68%	30%	2%	1.6	2.092	6.4

**Summary:**

**[00178]** For Table 2, comparative examples (1-4) show that clarity can be achieved in the aromatic-aliphatic polyesters (AAP1) and aromatic-aliphatic polyester (AAP1)/aliphatic polyester (AP1) blends without antimicrobial additives. This clarity is evident by the low haze values. Comparative example 5 shows a high haze increase (25.7%) for an aromatic-aliphatic polyester (AAP1) containing 2 weight percent of an antimicrobial additive. Examples 1-3 show decreasing levels of haze for an aromatic-aliphatic polyester (AAP1) containing 2 weight percent of an antimicrobial additive as the aliphatic polyester (AP1) content increases.

**[00179]** For Table 2, comparative examples (6-9) show that clarity can be achieved in the aromatic-aliphatic polyesters (AAP2) and aromatic-aliphatic polyester (AAP2)/aliphatic polyester (AP1) blends without antimicrobial additives. This clarity is evident by the low haze values. Comparative example 10 shows a high haze increase (39%) for an aromatic-aliphatic polyester (AAP2) containing 2 weight percent of an antimicrobial additive. Examples 4-6 show decreasing levels of haze for an aromatic-aliphatic polyester (AAP2) containing 2 weight percent of an antimicrobial additive as the aliphatic polyester (AP1) content increases.

For Table 3, the comparative examples with antimicrobial additives show very similar color (b\*) to the examples with antimicrobial additives. This is for illustration only as the actual color can be toned to the target color for the application.

**[00180]** The data in Table 4 shows color and haze data as a function of thickness. The part thickness is 2.4mm for or comparative examples (11, 13), examples (7-9) and examples (13-15). The part thickness is 1.6mm for comparative examples (12, 14), examples (10-12) and examples (16-18). Comparative example #11 shows a high haze level (24.1%) for an aromatic-aliphatic polyester (AAP1) containing 2 weight percent of an antimicrobial additive. Examples 7-9 show decreasing levels of haze for an aromatic-aliphatic polyester (AAP1) containing 2 weight percent of an antimicrobial additive as the aliphatic polyester (AP1) content increases.

**[00181]** Comparative example #12 shows a high haze level (16.9%) for an aromatic-aliphatic polyester (AAP1) containing 2 weight percent of an antimicrobial additive. Examples 10-12 show decreasing levels of haze for an aromatic-aliphatic polyester (AAP1) containing 2 weight percent of an antimicrobial additive as the aliphatic polyester (AP1) content increases.

**[00182]** Comparative example #13 shows a high haze level (35.3%) for an aromatic-aliphatic polyester (AAP2) containing 2 weight percent of an antimicrobial additive. Examples 13-15 show decreasing levels of haze for an aromatic-aliphatic polyester (AAP2) containing 2 weight percent of an antimicrobial additive as the aliphatic polyester (AP1) content increases.

**[00183]** Comparative example #14 shows a high haze level (25.8%) for an aromatic-aliphatic polyester (AAP2) containing 2 weight percent of an antimicrobial additive. Examples 16-18 show decreasing levels of haze for an aromatic-aliphatic polyester (AAP2) containing 2 weight percent of an antimicrobial additive as the aliphatic polyester (AP1) content increases.

## **Compounding**

**[00184]** The materials were dried separately with the aliphatic-aromatic polyester being dried at 85 degree celsius for 8 hours in a desiccant drying system and the aliphatic polyester was dried at 65 degree celsius for 8 hrs in a desiccant drying system. The antimicrobial additive was used without additional drying. The aliphatic-aromatic copolyester was cooled to 65C prior to hand blending with the aliphatic polyester and the antimicrobial additive. Blended samples were compounded on a Prism Eurolab 16, which is a 16mm twin-screw extruder manufactured by Thermo Electron Corporation.. A "medium shear" screw configuration was used. The barrel zone temperatures were set 300 degrees celsius except for Zone 1 which was set at 260 degrees celsius respectively. The feed zone was cooled with circulating water and the die that was set at 300 degrees celsius. The screw speed was 285 rpm and torque outputs on the machine ranged between 70 and 100 percent. All materials were



fed at barrel zone 1 of the twin screw. The extrudate from the twin screw was forced through a pelletizing rod type forming a strand that was cooled by a water bath. The first 5 minutes of extrudate was not collected in order to ensure the extruder had been adequately purged. Samples were collected after the strands were quenched in a water bath and chopped into pellets using a Conair pelletizing cutter.

### ***Injection Molding***

**[00185]** The compounded samples were molded on a MINI-JECTOR Injection Molder Model 55.1E. The processing temperature was 282 degrees celsius for the rear zone and 293 degrees celsius for both the front zone and the nozzle. Before molding, pellets were dried in a mechanical convection oven at 88 C for 4 hours. The molded parts were 38mm long by 38mm wide by 3.2mm thick. The mold temperature was set at 37 degrees celsius. The materials had an overall cycle time between 45 and 55 seconds.

**[00186]** Haze of the molded samples was measured using a Hunterlab Ultrascan Pro using method ASTM D1003 method A. The haze data is reported in Table 5.

TABLE 5

<b>Example</b>	<b>Aromatic-Aliphatic Polyester Type</b>	<b>Aromatic-Aliphatic Polyester (wt %)</b>	<b>AP1 (wt %)</b>	<b>SR12 (wt %)</b>	<b>Haze %</b>
CE #15	AAP2	96%	<b>0%</b>	4%	72.7
CE #16	AAP1	96%	<b>10%</b>	4%	56.5
EX #19	AAP1	80%	<b>18%</b>	2%	16.1
EX #20	AAP1	78%	<b>18%</b>	4%	26.5
EX #21	AAP1	74%	<b>18%</b>	8%	44.2
EX #22	AAP1	72%	<b>26%</b>	2%	13.2
EX #23	AAP1	70%	<b>26%</b>	4%	25.5
EX #24	AAP1	66%	<b>26%</b>	8%	42.4

**[00187]** The data in Table 5 show haze data as a function of additive loading at a constant part thickness of 3.2mm. Comparative example #15 shows high haze level (72.7%) for an aromatic-aliphatic polyester (AAP1) containing 4 weight percent of the antimicrobial additive. Likewise, comparative example #16 shows high haze level (56.5%) for an aromatic-aliphatic polyester (AAP2) containing 4 weight percent of the antimicrobial additive. However, all the examples show less than 30% haze at a comparable additive loading of 4 weight percent of the antimicrobial additive and less than 50% for a higher loading of the antimicrobial additive.

**[00188]** The invention has been described in detail with reference to the embodiments disclosed herein, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

**We claim:**

1. A polymer blend comprising:

(A) about 1% by weight to about 99% by weight of at least one polymer (A) comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of terephthalic acid residues;
- (b) 0 to 30 mole % of residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising:

- (a) 5 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
- (b) 40 to 95 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %;

(B) about 1% by weight to about 99% by weight of at least one polymer (B) comprising:

(1) a dicarboxylic acid component comprising:

- (a) 70 to 100 mole % of 1, 4-cyclohexanedicarboxylic acid residues;
- (b) 0 to 30 mole % of residues of at least one aromatic dicarboxylic acid having up to 20 carbon atoms; and
- (c) 0 to 30 mole % of residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(2) a glycol component comprising 50 to 100 mole % of 1,4-cyclohexanedimethanol residues,

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

(C) about 0.01% by weight to about 20% by weight of at least one antimicrobial agent chosen from at least one of: silver oxides, silver zirconium phosphates, silver glass, silver silicas, or combinations thereof; said weight percentages being based on the total weight of the polymer blend.

2. The polymer blend of Claim 1 wherein the glycol component of polymer (A) comprises:

- i) 15 to 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
- ii) 50 to 85 mole % of 1,4-cyclohexanedimethanol residues.

3. The polymer blend of Claim 1 wherein the glycol component of polymer (A) comprises:

- i) 15 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
- ii) 60 to 85 mole % of 1,4-cyclohexanedimethanol residues.

4. The polymer blend of Claim 1 wherein the glycol component of polymer (A) comprises:

- i) 20 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
- ii) 60 to 80 mole % of 1,4-cyclohexanedimethanol residues.

5. The polymer blend of Claim 1 wherein the glycol component of polymer (A) comprises:

- i) 20 to 30 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
- ii) 70 to 80 mole % of 1,4-cyclohexanedimethanol residues.

6. The polymer blend of Claim 1 wherein the glycol component of polymer (A) comprises:

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- i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and
- ii) 60 to 70 mole % of 1,4-cyclohexanedimethanol residues.

7. The polymer blend of Claim 1 wherein the glycol component of polymer (A) comprises at least one of: ethylene glycol, diethylene glycol, 1,2-propanediol, 1,3-propanediol, neopentyl glycol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, and p-xylene glycol.

8. The polymer blend of Claim 1 wherein the glycol component of polymer (B) comprises at least one of: 2,2,4,4,-tetramethyl-1,3-cyclobutanediol, ethylene glycol, diethylene glycol, 1,2-propanediol, 1,3-propanediol, neopentyl glycol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, and p-xylene glycol.

9. The polymer blend of Claim 1 wherein the glycol component of polymer (B) is chosen from at least one of: 2,2,4,4,-tetramethyl-1,3-cyclobutanediol, ethylene glycol, and neopentyl glycol.

10. The polymer blend of Claim 1 wherein the glycol component of polymer (B) comprises 1, 4-cyclohexanedimethanol residues in the amount of 60 to 100 mole %.

11. The polymer blend of Claim 1 wherein the glycol component of polymer (B) comprises 1,4-cyclohexanedimethanol residues in the amount of 80 to 100 mole %.

12. The polymer blend of Claim 1 wherein the acid component of polymer (B) comprises 1, 4-cyclohexanedicarboxylic acid residues in the amount of 80 to 100 mole %.

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13. The polymer blend of Claim 1 wherein the acid component of polymer (B) comprises 1, 4-cyclohexanedicarboxylic acid residues in the amount of 90 to 100 mole %.
14. The polymer blend of Claim 1 wherein the haze value of the blend is from 0 to 50% according to ASTM Method D1003.
15. The polymer blend of Claim 1 wherein the haze value of the blend is from 0 to 30% according to ASTM Method D1003.
16. The polymer blend of Claim 1 wherein the haze value of the blend is from 0 to 15% according to ASTM Method D1003.
17. The polymer blend of Claim 1 wherein the weight percentage of Polymer A in the blend is from about 51 weight% to about 99 weight%.
18. The polymer blend of Claim 1 wherein the weight percentage of Polymer A in the blend is from about 60 weight% to about 90 weight%.
19. The polymer blend of Claim 1, wherein said polymer A has a Tg of 90 to 140°C.
20. The polymer blend of Claim 1, wherein said polymer A has a Tg of 90 to 130°C.

# INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/021022

## A. CLASSIFICATION OF SUBJECT MATTER

INV. C08L67/02

ADD.

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010/099828 A1 (STACK GARY MICHAEL [US] ET AL) 22 April 2010 (2010-04-22) paragraph [0574] - paragraph [0581]; examples 1, 2; tables 1, 2 -----	1-20
A	DE 10 2007 003662 A1 (REBAC GMBH [DE]) 24 July 2008 (2008-07-24) paragraph [0005] - paragraph [0062]; claims 1, 4 -----	1-20
A	WO 2007/008365 A1 (EASTMAN CHEM CO [US]) 18 January 2007 (2007-01-18) paragraph [00114] - paragraph [00116]; claim 1; example 43; table 3 -----	1-20
A	US 2005/079372 A1 (SCHMAL MICHAEL D [US] ET AL) 14 April 2005 (2005-04-14) claims 1, 3 -----	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

### \* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

13 April 2012

Date of mailing of the international search report

25/04/2012

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040,  
Fax: (+31-70) 340-3016

Authorized officer

Enescu, Cristina

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2012/021022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010099828 A1	22-04-2010	NONE	
DE 102007003662 A1	24-07-2008	NONE	
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		WO 2007008365 A1	18-01-2007
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