polycarbonate. Furthermore, the metal from the catalyst used in the formation of the diaryl carbonate can cause corrosion of the reaction vessel that can result in a further source of metal corrosion, in addition to any degradation of the reaction vessel that can occur independently of the metal catalyst.

[0003] A purified diaryl carbonate reactant is therefore desirable in the production of polycarbonate for use in high transparency applications.

BRIEF SUMMARY

[0004] Disclosed herein are purified diaryl carbonates, methods of making polycarbonate, and the polycarbonate made therefrom.

[0004a] In one aspect, there is provided a method for producing a polycarbonate comprising: reacting a diaryl carbonate with a dihydroxy compound to form a polycarbonate, wherein the polycarbonate comprising a metal contaminant comprises: less than or equal to 500 ppb of molybdenum based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of vanadium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of chromium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 75 ppb of titanium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 375 ppb of niobium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of nickel based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 750 ppb of zirconium based on the total weight of the diaryl carbonate and the metal contaminant; and less or equal to 10 ppb iron based on the total weight of the diaryl carbonate and the metal contaminant.

[004b] In another aspect, there is provided a polycarbonate made by the method disclosed herein.

[0004c] In yet another aspect there is provided a diaryl carbonate comprising a metal contaminant comprising: less than or equal to 500 ppb of molybdenum based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of vanadium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of chromium based on the total weight of the diaryl carbonate ad the metal contaminant; less than or equal to 75 ppb of titanium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 375 ppb of niobium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of nickel based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 10 ppb of zirconium based on the total weight of the diaryl carbonate and the metal contaminant; and less or equal to 10 ppb iron based on the total weight of the diaryl carbonate and the metal contaminant.

[0004d] In another aspect, there is provided a method for producing a polycarbonate comprising: reacting a diaryl carbonate with a dihydroxy compound to form a polycarbonate, wherein the polycarbonate comprises: less than or equal to 1,000 ppb of molybdenum; less than or equal to 33 ppb of vanadium; less than or equal to 33 ppb of chromium; less than or equal to 33 ppb of nickel; and less or equal to 10 ppb iron.

[0004e] In still another aspect, there is provided, a method for producing a polycarbonate comprising: selecting a diaryl carbonate based on a maximum contaminant content and reacting the diaryl carbonate with a dihydroxy compound to form a melt polycarbonate comprising a metal contaminant comprising less than or equal to 500 ppb of molybdenum based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of vanadium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of chromium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 75 ppb of titanium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 375 ppb of niobium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of nickel based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 10 ppb of zirconium based on the total weight of the diaryl carbonate and the metal contaminant; and less or equal to 10 ppb iron based on the total weight of the diaryl carbonate and the metal contaminant; wherein the reacting occurs in at least one reactor, and wherein the reactor comprises a reactor contaminant.

[0005] In an embodiment, a purified diaryl carbonate comprises less than or equal to 500 ppb of molybdenum based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of vanadium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of chromium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 75 ppb of titanium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 375 ppb of niobium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of nickel based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 750 ppb of zirconium; and less or equal to 10 ppb iron based on the total weight of the diaryl carbonate and the metal contaminant.

[0006] In an embodiment, a method for producing a polycarbonate comprises reacting a diaryl carbonate with a dihydroxy compound to form a polycarbonate, wherein the polycarbonate comprises: less than or equal to 500 ppb of molybdenum based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of vanadium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of chromium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 75 ppb of titanium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 375 ppb of niobium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of nickel based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 750 ppb of zirconium based on the total weight of the diaryl carbonate

CLAIMS

1. A method for producing a polycarbonate comprising:

reacting a diaryl carbonate with a dihydroxy compound to form a polycarbonate, wherein the polycarbonate comprises:

less than or equal to 500 ppb of molybdenum based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of vanadium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of chromium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 75 ppb of titanium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 375 ppb of niobium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of nickel based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 750 ppb of zirconium based on the total weight of the diaryl carbonate and the metal contaminant; and

less or equal to 10 ppb iron based on the total weight of the diaryl carbonate and the metal contaminant.

2. A method for producing a polycarbonate comprising: reacting a diaryl carbonate with a dihydroxy compound to form a polycarbonate. The polycarbonate comprises: less than or equal to 1,000 ppb of molybdenum; less than or equal to 33 ppb of vanadium; less than or equal to 33 ppb of chromium; less than or equal to 33 ppb of nickel; and less or equal to 10 ppb iron.

3. A method for producing a polycarbonate comprising:

selecting a diaryl carbonate based on a maximum contaminant content and reacting the diaryl carbonate with a dihydroxy compound to form a melt polycarbonate comprising less than or equal to 500 ppb of molybdenum based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of vanadium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of chromium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 75 ppb of titanium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 375 ppb of niobium based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 33 ppb of nickel based on the total weight of the diaryl carbonate and the metal contaminant; less than or equal to 10 ppb of zirconium based on the total weight of the diaryl carbonate and the metal contaminant; and less or equal to 10 ppb iron based on the total weight of the diaryl carbonate and the metal contaminant; wherein the reacting occurs in at least one reactor, and wherein the reactor comprises a reactor contaminant.

4. The method of any of Claims 1-3, wherein the polycarbonate comprises less than or equal to 20 ppb vanadium.

5. The method of any of Claims 1-4, wherein the polycarbonate comprises less than or equal to 20 ppb chromium.

6. The method of any of Claims 1-5, wherein the polycarbonate comprises less than or equal to 20 ppb titanium.

7. The method of any of Claims 1-6, wherein the polycarbonate comprises less than or equal to 20 ppb nickel.

8. The method of any of Claims 1-7, wherein the polycarbonate comprises less than or equal to 10 ppb zirconium.

9. The method of any of Claims 1-8, wherein the polycarbonate comprises less than or equal to 20 ppb niobium.

10. The method of any of Claims 1-9, wherein the polycarbonate comprises less than or equal to 5 ppb iron.

11. The method of any of Claims 1-10, wherein the diaryl carbonate comprises diphenyl carbonate.

12. The method of any of Claims 1-11, wherein the dihydroxy compound is of the formula $HO-R^1-OH$, wherein R^1 is a C_{6-30} aromatic group.

13. The method of any of Claims 1-12, wherein the polycarbonate has a yellowness index of less than or equal to 3 as determined by ASTM D1925, after 2 hours of aging at 250°C.

14. The method of any of Claims 1-13, wherein the polycarbonate has a yellowness index of less than or equal to 2.5 as determined by ASTM D1925, after 2 hours of aging at 250°C.

15. The method of any of Claims 1-14, further comprising preparing the diaryl carbonate.

16. The method of Claim 15, wherein the preparing comprises the step of decarbonylating a diaryl oxalate in the presence of a decarbonylation catalyst.

17. The method of Claim 16, wherein the diaryl oxalate has the formula: ArO(C=O)-(C=O)OAr, where each Ar independently is an aromatic hydrocarbon group having 6 to 14 carbon atoms.

18. The method of any of Claims 16-17, wherein the catalyst comprises an organic phosphorus compound.

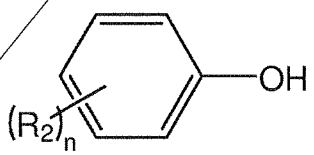
19. The method of Claim 15, wherein the preparing comprises the reacting an aromatic hydroxy compound and carbon monoxide in the presence of oxygen and a catalyst.

20. The method of Claim 19 wherein the catalyst comprises a palladium catalyst.

21. The method of Claim 15, wherein the preparing comprises reacting an aromatic hydroxy compound with phosgene in the presence of a transesterification catalyst.

22. The method of Claim 15, wherein the preparing comprises reacting an aromatic hydroxy compound with a dialkyl carbonate in the presence of a transesterification catalyst.

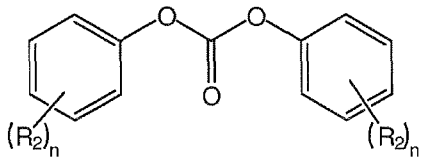
23. The method of any of Claims 19-22, wherein the aromatic hydroxy compound has the formula (III)



(III)

wherein n is an integer 1 to 3 and each R_2 is independently a C_{1-34} alkyl, a C_{1-34} alkoxy, a C_{5-34} cycloalkyl, a C_{7-34} alkylaryl, a C_{6-34} aryl, a halogen radical, or –COO–R', wherein R' is H, a C_{1-34} alkyl, C_{1-34} alkoxy, C_{5-34} cycloalkyl, C_{7-34} alkylaryl, or C_{6-34} aryl.

24. The method of any of Claims 1-23, wherein the diaryl carbonate has the formula (I)



(I)

wherein n is an integer 1 to 3 and each R_2 is independently, a C_{1-34} alkyl, a C_{1-34} alkoxy, a C_{5-34} cycloalkyl, a C_{7-34} alkylaryl; a C_{6-34} aryl; a halogen radical, or –COO–R', wherein R' is H, a C_{1-34} alkyl, a C_{1-34} alkoxy, a C_{5-34} cycloalkyl, a C_{7-34} alkylaryl; or a C_{6-34} aryl.

25. The method of any of Claims 1-24, further comprising adding the diaryl carbonate and the dihydroxy compound to a polymerization unit before reacting, wherein the diaryl carbonate and/or the dihydroxy compound is added to the polymerization unit as a mixture with acetone.

26. The method of any of Claims 1-25, wherein the dihydroxy compound is bisphenol A, and further comprising forming the dihydroxy compound by:

reacting phenol with acetone in the presence of a sulfur containing promoter to obtain a reaction mixture comprising bisphenol A, phenol, and the promoter;

after reacting the phenol with the acetone, cooling the reaction mixture to form a crystal stream comprising crystals of bisphenol A and phenol;

separating the crystals from the crystal steam; melting the crystals to form a molten stream of bisphenol A, phenol, and sulfur;

contacting the molten stream with a base to reduce a sulfur concentration in the molten stream and form a reduced sulfur stream; and

removing phenol from the reduced sulfur stream to form a bisphenol A product.

27. The method of Claim 26, further comprising:

prior to forming the crystal stream, cooling the reaction mixture to form an initial crystal stream comprising initial crystals of bisphenol A and phenol;

separating the initial crystals from the initial crystal steam;

melting the initial crystals to form an initial molten stream; and

then performing the cooling to form the crystal steam in accord with Embodiment 25.

28. The method of any of Claims 1-27, further comprising extruding the polycarbonate, wherein phosphorous acid is added to the extruder.

29. The method of any of Claims 1-28, wherein the polycarbonate comprises less than or equal to 33 ppb of molybdenum

30. The polycarbonate made by the method of any of Claims 1-29.

31. A diaryl carbonate comprising:

less than or equal to 500 ppb of molybdenum based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of vanadium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of chromium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 75 ppb of titanium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 375 ppb of niobium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of nickel based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 10 ppb of zirconium based on the total weight of the diaryl carbonate and the metal contaminant; and

less or equal to 10 ppb iron based on the total weight of the diaryl carbonate and the metal contaminant.

32. The diaryl carbonate of Claim 31, wherein the diaryl carbonate comprises less than 20 ppb of vanadium based on the total weight of the diaryl carbonate and any metal contaminant.

CLAIMS

1. A method for producing a polycarbonate comprising:

reacting a diaryl carbonate with a dihydroxy compound to form a polycarbonate,

wherein the polycarbonate comprising a metal contaminant comprises:

less than or equal to 500 ppb of molybdenum based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of vanadium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of chromium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 75 ppb of titanium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 375 ppb of niobium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of nickel based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 750 ppb of zirconium based on the total weight of the diaryl carbonate and the metal contaminant; and

less or equal to 10 ppb iron based on the total weight of the diaryl carbonate and the metal contaminant.

2. The method of claim 1, wherein the polycarbonate comprises less than or equal to 20 ppb vanadium and/or less than or equal to 20 ppb chromium and/or less than or equal to 20 ppb titanium and/or less than or equal to 20 ppb nickel and/or less than or equal to 10 ppb zirconium and/or less than or equal to 20 ppb niobium and/or less than or equal to 5 ppb iron.

3. The method of claim 1, wherein the diaryl carbonate comprises diphenyl carbonate.

4. The method of claim 1, wherein the dihydroxy compound is of the formula HO—R^1—OH, wherein R^1 is a C_{6-30} aromatic group.

5. The method of claim 1, wherein the polycarbonate has a yellowness index of less than or equal to 3 as determined by ASTM D1925, after 2 hours of aging at 250° C.

6. The method of claim 1, further comprising preparing the diaryl carbonate.

7. The method of claim 6, wherein the preparing comprises the step of decarbonylating a diaryl oxalate in the presence of a decarbonylation catalyst.

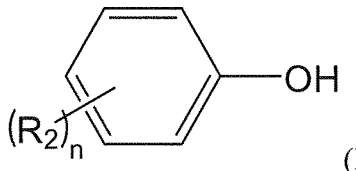
8. The method of claim 7, wherein the diaryl oxalate has the formula: ArO(C=O)—(C=O)OAr, where each Ar independently is an aromatic hydrocarbon group having 6 to 14 carbon atoms.

9. The method of claim 6, wherein the preparing comprises the reacting an aromatic hydroxy compound and carbon monoxide in the presence of oxygen and a catalyst.

10. The method of claim 6, wherein the preparing comprises reacting an aromatic hydroxy compound with phosgene in the presence of a transesterification catalyst.

11. The method of claim 6, wherein the preparing comprises reacting an aromatic hydroxy compound with a dialkyl carbonate in the presence of a transesterification catalyst.

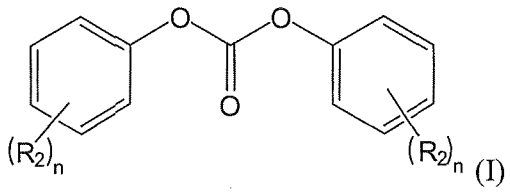
12. The method of claim 9, wherein the aromatic hydroxy compound has the formula (III)



(III)

wherein n is an integer 1 to 3 and each R_2 is independently a C_{1-34} alkyl, a C_{1-34} alkoxy, a C_{5-34} cycloalkyl, a C_{7-34} alkylaryl, a C_{6-34} aryl, a halogen radical, or —COO—R′, wherein R′ is H, a C_{1-34} alkyl, C_{1-34} alkoxy, C_{5-34} cycloalkyl, C_{7-34} alkylaryl, or C_{6-34} aryl.

13. The method of claim 1, wherein the diaryl carbonate has the formula (I)



(I)

wherein n is an integer 1 to 3 and each R_2 is independently, a C_{1-34} alkyl, a C_{1-34} alkoxy, a C_{5-34} cycloalkyl, a C_{7-34} alkylaryl; a C_{6-34} aryl; a halogen radical, or —COO—R′, wherein R′ is H, a C_{1-34} alkyl, a C_{1-34} alkoxy, a C_{5-34} cycloalkyl, a C_{7-34} alkylaryl; or a C_{6-34} aryl.

14. The method of claim 1, further comprising adding the diaryl carbonate and the dihydroxy compound to a polymerization unit before reacting, wherein the diaryl carbonate and/or the dihydroxy compound is added to the polymerization unit as a mixture with acetone.

15. The method of claim 1, wherein the dihydroxy compound is bisphenol A, and further comprising forming the dihydroxy compound by:

reacting phenol with acetone in the presence of a sulfur containing promoter to obtain a reaction mixture comprising bisphenol A, phenol, and the promoter;

after reacting the phenol with the acetone, cooling the reaction mixture to form a crystal stream comprising crystals of bisphenol A and phenol;

separating the crystals from the crystal steam; melting the crystals to form a molten stream of bisphenol A, phenol, and sulfur;

contacting the molten stream with a base to reduce a sulfur concentration in the molten stream and form a reduced sulfur stream; and

removing phenol from the reduced sulfur stream to form a bisphenol A product.

16. The method of claim 15, further comprising:

prior to forming the crystal stream, cooling the reaction mixture to form an initial crystal stream comprising initial crystals of bisphenol A and phenol;

separating the initial crystals from the initial crystal steam;

melting the initial crystals to form an initial molten stream; and

then performing the cooling to form the crystal steam in accordance with claim 14.

17. The method of claim 1, further comprising extruding the polycarbonate, wherein phosphorous acid is added to the extruder.

18. The polycarbonate made by the method of claim 1.

19. A diaryl carbonate comprising a metal contaminant comprising:

less than or equal to 500 ppb of molybdenum based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of vanadium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of chromium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 75 ppb of titanium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 375 ppb of niobium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of nickel based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 10 ppb of zirconium based on the total weight of the diaryl carbonate and the metal contaminant; and

less or equal to 10 ppb iron based on the total weight of the diaryl carbonate and the metal contaminant.

20. The diaryl carbonate of claim 19, wherein the diaryl carbonate comprises less than 20 ppb of vanadium based on the total weight of the diaryl carbonate and any metal contaminant.

21. A method for producing a polycarbonate comprising: reacting a diaryl carbonate with a dihydroxy compound to form a polycarbonate, wherein the polycarbonate comprises: less than or equal to 1,000 ppb of molybdenum; less than or equal to 33 ppb of vanadium; less than or equal to 33 ppb of chromium; less than or equal to 33 ppb of nickel; and less or equal to 10 ppb iron.

22. A method for producing a polycarbonate comprising:

selecting a diaryl carbonate based on a maximum contaminant content and reacting the diaryl carbonate with a dihydroxy compound to form a melt polycarbonate comprising a metal contaminant comprising less than or equal to 500 ppb of molybdenum based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of vanadium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of chromium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 75 ppb of titanium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 375 ppb of niobium based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 33 ppb of nickel based on the total weight of the diaryl carbonate and the metal contaminant;

less than or equal to 10 ppb of zirconium based on the total weight of the diaryl carbonate and the metal contaminant; and

less or equal to 10 ppb iron based on the total weight of the diaryl carbonate and the metal contaminant; wherein the reacting occurs in at least one reactor, and wherein the reactor comprises a reactor contaminant.