Claims

1. A process for producing a 2,5-furandicarboxylic acid (FDCA) pathway product from a furanic oxidation substrate, the process comprising:

(a) contacting an oxidation feedstock comprising a furanic oxidation substrate and an oxidation solvent with oxygen in the presence of a heterogeneous oxidation catalyst under conditions sufficient to form a reaction mixture for oxidizing the furanic oxidation substrate to an FDCA pathway product, and producing the FDCA pathway product,

wherein the oxidation solvent is a multi-component solvent comprising water and a water-miscible aprotic organic solvent,

wherein no base is added to the reaction mixture during contacting step (a),

wherein the heterogeneous oxidation catalyst comprises a solid support and a noble metal, and

wherein the solid support comprises a plurality of pores and a specific surface area in the range of from or any number in between 20 m^2/g to 500 m^2/g.

2. The process of claim 1, wherein the noble metal is selected from the group consisting of platinum, gold, and a combination thereof.

3. The process of claim 1, wherein the water-miscible aprotic organic solvent is selected from the group consisting of tetrahydrofuran, a glyme, dioxane, a dioxolane, dimethylformamide, dimethylsulfoxide, sulfolane, acetone, N-methyl-2-pyrrolidone ("NMP"), methyl ethyl ketone ("MEK"), and gamma-valerolactone;

and, if the water-miscible aprotic organic solvent is a glyme, then the glyme is selected from the group consisting of a monoglyme (1,2-dimethoxyethane), ethyl glyme, diglyme (diethylene glycol dimethyl ether), ethyl diglyme, triglyme, butyl diglyme, tetraglyme, and a polyglyme.

4. The process of claim 1, wherein the oxidation feedstock comprises the furanic oxidation substrate at a concentration of at least 5% by weight.

5. The process of claim 1, wherein the heterogeneous oxidation catalyst comprises the metal at a loading in the range of from or any number in between 0.3% to 5% by weight of the heterogeneous oxidation catalyst.

6. The process of claim 1, wherein the solid support comprises a material selected from the group consisting of a metal oxide, a carbonaceous material, a polymer, a metal silicate, a metal carbide, and any combination of two or more thereof.

7. The process of claim 1, wherein the solid support comprises a specific surface area in the range of from or any number in between 25 m^2/g to 350 m^2/g.

8. The process of claim 1, wherein the solid support comprises a pore volume wherein at least 50% of the pore volume is from pores having a pore diameter in the range of from or any number in between 5 nm to 100 nm.

9. The process of claim 1, wherein the oxygen is present at a molar ratio of oxygen:furanic oxidation substrate in the range of from or any number in between 2:1 to 10:1.

10. The process of claim 1, wherein the contacting step is carried out at a temperature in the range of from or any number in between 50°C to 200°C.

11. The process of claim 1, wherein the FDCA pathway product is produced at a yield of at least 80%.

12. The process of claim 1, further comprising a second oxidation step, wherein the second oxidation step comprises:

(b) contacting a second oxidation feedstock comprising a second furanic oxidation substrate and a second oxidation solvent with oxygen in the presence of a second heterogeneous oxidation catalyst under conditions sufficient to form a second reaction mixture for oxidizing the second furanic oxidation substrate to produce a second FDCA pathway product, and producing the second FDCA pathway product,

wherein (the first) contacting step (a) produces a first FDCA pathway product that is an FDCA pathway intermediate compound, either alone or together with FDCA,

wherein the second furanic oxidation substrate is the first FDCA pathway product,

wherein the second reaction mixture is substantially free of added base, and

wherein the second heterogeneous oxidation catalyst comprises a second solid support and a second noble metal, that may be the same or different from the (first) noble metal in step (a), and

wherein the second solid support comprises a plurality of pores and a specific surface area in the range of from or any number in between 20 m^2/g to 500 m^2/g.

13. The process of claim 12, wherein the noble metal is selected from the group consisting of platinum, gold, and a combination thereof.

14. The process of claim 1, wherein the FDCA pathway product is FDCA.

15. The process of claim 1, further comprising:

(a^o) prior to step (a), contacting a carbohydrate feedstock comprising a sugar and a dehydration solvent with a catalyst under conditions sufficient to form a reaction mixture for dehydrating the sugar to produce the furanic oxidation substrate, wherein the furanic oxidation substrate is present in a dehydration product solution that comprises the furanic oxidation substrate and the dehydration solvent.

16. A process for producing a furanic oxidation substrate, the process comprising:

contacting a carbohydrate feedstock comprising a sugar and a dehydration solvent with an acid catalyst under conditions sufficient to form a dehydration reaction mixture for dehydrating the sugar to produce a furanic oxidation substrate, wherein the acid catalyst is an acid selected from the group consisting of HBr, H_2SO_4, HNO_3, HCl, HI, H_3PO_4, triflic acid, methansulfonic acid, benzenesulfonic acid, and p-toluene sulfonic acid,

wherein when the acid catalyst is not HBr, the dehydration reaction mixture further comprises a bromide salt, and

wherein the dehydration solvent comprises N-methyl-pyrrolidone (NMP).

17. The process of claim 16, wherein the sugar is fructose and the furanic oxidation substrate is HMF.

18. The process of claim 16, further comprising contacting the carbohydrate feedstock comprising the sugar and the dehydration solvent with the acid catalyst and $ZnCl_2$ or $ZnBr_2$ under conditions sufficient to form a dehydration reaction mixture for dehydrating the sugar to produce a furanic oxidation substrate.

19. The process of claim 1, wherein the solid support comprises a specific surface area in the range of from or any number in between 20 m^2/g to 50 m^2/g.

20. The process of claim 19, wherein the solid support comprises a specific surface area in the range of from or any number in between 20 m^2/g to 40 m^2/g.

21. The process of claim 4, wherein the water-miscible aprotic organic solvent is a glyme.

22. The process of claim 21, wherein the water-miscible aprotic organic solvent is 1,2-dimethoxyethane ("DME").

23. The process of claim 21, wherein the water-miscible aprotic organic solvent is diglyme.

24. The process of claim 3, wherein the water-miscible aprotic organic solvent is dioxane.

25. The process of claim 3, wherein the water-miscible aprotic organic solvent is NMP.

26. The process of claim 3, wherein the water-miscible aprotic organic solvent is MEK.

27. The process of claim 1, wherein the weight percent ratio of water-miscible aprotic organic solvent:water is in the range of from or any number in between 70:30 to 20:80.

28. The process of claim 27, wherein the weight percent ratio of water-miscible aprotic organic solvent:water is in the range of from or any number in between 60:40 to 40:60.

29. The process of claim 16, wherein the contacting step is carried out at a temperature of less than 110°C.