CLAIMS

1. A process for preparing 2,5-bis-hydroxymethylfuran (BHMF) from 5-hydroxymethylfurfural (HMF) comprising:

reacting the 5-hydroxymethylfurfural (HMF) with hydrogen in a continuous flow reactor in the presence of an organic solvent selected from the group consisting of alcohols, esters, ethers and mixtures thereof, optionally comprising water, and a heterogeneous reduction catalyst comprising at least one metal selected from the group consisting of Ni, Co, Cu, Ag and Pt or a combination thereof to form the 2,5-bis-hydroxymethylfuran (BHMF) over an on-stream period of at least 150 hours.

2. The process of claim 1, wherein the 2,5-bis-hydroxymethylfuran (BHMF) is formed with at least about 90% selectivity and at least 85% conversion of the 5-hydroxymethylfurfural (HMF).

3. The process of claim 1, wherein the organic solvent comprises less than about 25 weight % water.

4. The process of claim 1, wherein the heterogeneous reduction catalyst further comprises a modifier selected from the group consisting of Mn, Co, Au, W, Cu, Zn, Mo, Sb, Bi and Pb.

5. The process of claim 1, wherein the heterogeneous reduction catalyst further comprises a catalyst support.

6. The process of claim 1, wherein the 5-hydroxymethylfurfural (HMF) is reacted with hydrogen at a temperature in a range of 50°C to 150°C and at a pressure in a range of 50 psi to 2000 psi.

7. The process of claim 1, further comprising reacting the 2,5-bis-hydroxymethylfuran (BHMF) with hydrogen in a continuous flow reactor in the presence of an organic solvent selected from the group consisting of alcohols, esters, ethers and mixtures thereof, optionally comprising water, and a heterogeneous reduction catalyst comprising at least one metal selected from the group consisting of Ni, Co, Pd, Pt and Ru or a combination thereof to form 2,5-bis-hydroxymethyltetrahydrofuran (BHMTHF).

8. The process of claim 7, further comprising reacting the 2,5-bis-hydroxymethyltetrahydrofuran (BHMTHF) with hydrogen in a continuous flow reactor in the presence of an aqueous or organic solvent selected from the group consisting of water, alcohols, esters, ethers, ketones and mixtures thereof, and a heterogeneous reduction catalyst comprising at least one metal selected from the group consisting of Ni, Co, Pt and Ru or a combination thereof to form 1,2,6-hexanetriol (HTO).

9. The process of claim 1, further comprising reacting the 2,5-bis-hydroxymethylfuran (BHMF) with hydrogen in a continuous flow reactor at a pressure in a range of 50 psi to 2000 psi in the presence of an aqueous or organic solvent selected from the group consisting of water, alcohols, esters, ethers and mixtures thereof, and a heterogeneous reduction catalyst comprising at least one metal selected from the group consisting of Co, Cu, Pt, and Pd or a combination thereof to form 1,2,6-hexanetriol (HTO).

10. The process of claim 8, further comprising reacting the 1,2,6-hexanetriol (HTO) with hydrogen in a continuous flow reactor in the presence of a heterogeneous reduction catalyst comprising at least one metal selected from the group consisting of Ni, Co, Cu, Ag, Pt and Ru or a combination thereof to form 1,6-hexanediol (HDO).

11. A process for preparing 1,2,6-hexanetriol (HTO) from 5-hydroxymethylfurfural (HMF) comprising:

(a) feeding 5-hydroxymethylfurfural (HMF) to a continuous flow reactor at a concentration of greater than about 5 weight percent in a first organic solvent selected from the group consisting of alcohols, esters, ethers and mixtures thereof, optionally comprising water, for an on-stream period of at least 150 hours;

(b) reacting the 5-hydroxymethylfurfural (HMF) with hydrogen in the continuous flow reactor in the presence of the first organic solvent and a first heterogeneous reduction catalyst comprising at least one metal selected from the group consisting of Ni, Co, Cu, Ag and Pt or a combination thereof to form 2,5-bis-hydroxymethylfuran (BHMF) in a first reactor effluent stream or a first reactor zone effluent stream;

(c) reacting the 2,5-bis-hydroxymethylfuran (BHMF) with hydrogen, without isolation or purification of the 2,5-bis-hydroxymethylfuran (BHMF) from the first reactor effluent stream or

the first reactor zone effluent stream, in the presence of a second heterogeneous reduction catalyst comprising at least one metal selected from the group consisting of Ni, Co, Pd, Pt and Ru or a combination thereof to form 2,5-bis-hydroxymethyltetrahydrofuran (BHMTHF) in a second reactor effluent stream or a second reactor zone effluent stream; and

(d) reacting the 2,5-bis-hydroxymethyltetrahydrofuran (BHMTHF) with hydrogen, without isolation or purification of the 2,5-bis-hydroxymethyltetrahydrofuran (BHMTHF) from the second reactor effluent stream or the second reactor zone effluent stream, in the presence of a third heterogeneous reduction catalyst comprising at least one metal selected from the group consisting of Ni, Co, Pt and Ru or a combination thereof to form the 1,2,6-hexanetriol (HTO).

12. A process for preparing 1,2,6-hexanetriol (HTO) from 5-hydroxymethylfurfural (HMF) comprising:

feeding the 5-hydroxymethylfurfural (HMF) to a continuous flow reactor at a concentration of greater than about 5 weight percent in a first organic solvent selected from the group consisting of alcohols, esters, ethers and mixtures thereof, optionally comprising water, for an on-stream period of at least 150 hours;

reacting the 5-hydroxymethylfurfural (HMF) with hydrogen in the continuous flow reactor in the presence of the first organic solvent and a first heterogeneous reduction catalyst comprising at least one metal selected from the group consisting of Ni, Co, Cu, Ag and Pt or a combination thereof to form 2,5-bis-hydroxymethylfuran (BHMF) in a first reactor effluent stream or a first reactor zone effluent stream; and

reacting the 2,5-bis-hydroxymethylfuran (BHMF) with hydrogen, without isolation or purification of the 2,5-bis-hydroxymethylfuran (BHMF) from the first reactor effluent stream or the first reactor zone effluent stream, in the presence of a second heterogeneous reduction catalyst comprising at least one metal selected from the group consisting of Ni, Co, Cu, Pt, Pd and Ru or a combination thereof to form the 1,2,6-hexanetriol (HTO).

13. A process for preparing 2,5-bis-hydroxymethylfuran (BHMF) from 5-hydroxymethylfurfural (HMF) comprising:

reacting the 5-hydroxymethylfurfural (HMF) with hydrogen in a continuous flow reactor at a pressure in a range of 50 psi to 2000 psi in the presence of

(i) an organic solvent selected from the group consisting of alcohols, esters, ethers and mixtures thereof, comprising less than about 25 weight % water, and

(ii) a heterogeneous reduction catalyst comprising Cu

to form the 2,5-bis-hydroxymethylfuran (BHMF) with at least about 90% selectivity and at least 85% 5-hydroxymethylfurfural (HMF) conversion.

14. A process for preparing 1,2,6-hexanetriol (HTO) from 5-hydroxymethylfurfural (HMF) comprising:

(a) reacting the 5-hydroxymethylfurfural (HMF) with hydrogen in a continuous flow reactor in the presence of

(i) a first organic solvent selected from the group consisting of alcohols, esters, ethers and mixtures thereof, comprising less than about 25 weight % water, and

(ii) a first heterogeneous reduction catalyst comprising Cu to form 2,5-bis-hydroxymethylfuran (BHMF);

(b) reacting the 2,5-bis-hydroxymethylfuran (BHMF) with hydrogen in the presence of

(i) a second organic solvent selected from the group consisting of alcohols, esters, ethers and mixtures thereof, comprising less than about 25 weight % water, and

(ii) a second heterogeneous reduction catalyst comprising Ni

to form 2,5-bis-hydroxymethyltetrahydrofuran (BHMTHF); and

(c) reacting the 2,5-bis-hydroxymethyltetrahydrofuran (BHMTHF) with hydrogen in the presence of

(i) a third organic solvent selected from the group consisting of alcohols, esters, ethers, ketones and mixtures thereof, comprising less than about 25 weight % water, and

(ii) a third heterogeneous reduction catalyst comprising Pt to form the 1,2,6-hexanetriol (HTO).

15. A process for preparing 1,6-hexanediol (HDO) from 5-hydroxymethylfurfural (HMF) comprising:

(a) reacting the 5-hydroxymethylfurfural (HMF) with hydrogen in a continuous flow reactor in the presence of

(i) a first organic solvent selected from the group consisting of alcohols, esters, ethers and mixtures thereof, comprising less than about 25 weight % water, and

(ii) a first heterogeneous reduction catalyst comprising at least one metal selected from the group consisting of Co, Mn, Ni, and Cu or a combination thereof to form 2,5-bis-hydroxymethyltetrahydrofuran (BHMTHF);

(b) reacting the 2,5-bis-hydroxymethyltetrahydrofuran (BHMTHF) with hydrogen in a continuous flow reactor the presence of

(i) a second organic solvent selected from the group consisting of alcohols, esters, ethers, ketones and mixtures thereof, comprising less than about 25 weight % water, and

(ii) a second heterogeneous reduction catalyst comprising Pt to form the 1,6-hexanetriol (HDO).

16. The process of claim 1 further comprising:

feeding the 5-hydroxymethylfurfural (HMF) through a guard bed comprising a transition metal to the continuous flow reactor.

17. The process of claim 1, wherein the organic solvent comprises an alcohol.

18. The process of claim 1, wherein the organic solvent comprises an ester.

19. The process of claim 1, wherein the organic solvent comprises an ether.

20. The process of claim 1, wherein the heterogeneous reduction catalyst comprises a combination of metals selected from the group consisting of Co-Cu, Ni-Cu, Ag-Ni, Ag-Co and Ag-Ru.