CLAIMS

What is claimed is:

1. A model predictive control method for operating a continuous, unmodulated, sequential, multi-catalytic reaction process, wherein the process is for converting carbohydrate to lower glycol of at least one of ethylene glycol and propylene glycol by sequential retro-aldol catalysis of carbohydrate to produce intermediates and hydrogenation catalysis of intermediates to the lower glycol, wherein each catalyst is subject to changes in performance in the course of the process, the catalytic reaction process comprising:

(i) continuously or intermittently introducing at a feed rate at least one raw material, wherein the raw material comprises carbohydrate and optionally a tracer precursor, into a reaction zone containing a medium,

(ii) maintaining the reaction zone under catalytic conversion conditions suitable for a first catalytic conversion to produce a medium containing an intermediate, wherein the first catalytic conversion is a retro-aldol reaction, said conditions including temperature, pressure, residence time, concentration of the first catalyst providing catalytically active species, and, optionally, pH and adjuvants,

(iii) contacting the medium containing the intermediate with a second catalyst, wherein the second catalyst is a hydrogenation catalyst, providing catalytically active species under conditions suitable for the other conversion to produce a chemical product, wherein the chemical product comprises at least one of ethylene glycol and propylene glycol said conditions including temperature, pressure, residence time, concentration of the second catalyst, and, optionally, pH and adjuvants; and

(iv) continuously or intermittently withdrawing medium containing the chemical product from contact with the second catalyst at a rate to provide a continuous process; wherein at least one byproduct is produced, and wherein the catalytic activity of at least one of the first catalyst and second catalyst is subject to performance change during the continuous operation,

said control method comprising:

(a) continuously or intermittently inputting predetermined process parameters from the process operation into a model predictive control apparatus having a control model;

(b) adjusting, as necessary to meet a desired process objective, manipulative inputs to the process; and, optionally

(c) adjusting the control model,

wherein:

(A) in element (a) the predetermined process parameters inputted comprise (I) the rate and concentration of feed of raw material in step (i) and the conversion efficiency of the raw material to the chemical product and (II) at least one of concentration of at least one:

by-product in the withdrawn medium,

concentration of intermediate in the withdrawn medium and

concentration of at least one tracer in the withdrawn medium

to reflect in control model data pertaining to the performances of the catalysts; and

(B) adjusting, as necessary to meet a desired process objective, at least one of: (I) the absolute amount of catalytically active species and relative amounts of each of the first catalyst and second catalyst, and (II) at least one of the rate of feed of the raw material and its concentration to the reaction zone as manipulative inputs.

2. The method of claim 1 wherein the medium is a liquid.

3. A method for operating a continuous, unmodulated, sequential, multi-catalytic reaction process, wherein the process is for converting carbohydrate to lower glycol of at least one of ethylene glycol and propylene glycol by sequential retro-aldol catalysis of carbohydrate to produce intermediates and hydrogenation catalysis of intermediates to the lower glycol, wherein each catalyst is subject to changes in performance in the course of the process, which methods adjust manipulative inputs to provide outputs within predetermined ranges, the catalytic reaction process comprising:

(i) continuously or intermittently introducing at a feed rate and concentration at least one raw material, wherein the raw material comprises carbohydrate and optionally a tracer precursor, into a reaction zone containing liquid medium,

(ii) maintaining the reaction zone under catalytic conversion conditions suitable for a first catalytic conversion to produce a liquid medium containing an intermediate, wherein the first catalytic conversion is a retro-aldol reaction, said conditions including temperature, pressure, residence time, concentration of the first catalyst providing catalytically active species, and, optionally, pH and adjuvants,

(iii) contacting the liquid medium containing the intermediate with a second catalyst, wherein the second catalyst is a hydrogenation catalyst, providing catalytically active species under conditions suitable for the other conversion to produce the chemical product, wherein the chemical product comprises at least one of ethylene glycol and propylene glycol, said conditions including temperature, pressure, residence time, concentration of the second catalyst, and, optionally, pH and adjuvants, and

(iv) continuously or intermittently withdrawing liquid medium containing chemical product from contact with the second catalyst at a rate to provide a continuous process;

wherein at least one byproduct is produced, and wherein the catalytic activity of at least one of the first catalyst and second catalyst is subject to performance change during the continuous operation, the method comprises:

(a) continuously or intermittently comparing predetermined process parameters from the process operation to predetermined windows for such operation; and

(b) adjusting, as necessary to meet a desired process objective, manipulative inputs to the process,

wherein in element (a) the predetermined process parameters inputted comprise (I) the rate and concentration of feed of raw material in step (i) and the conversion efficiency of the raw material to the chemical product and (II) at least one of concentration of at least one by-product in the withdrawn liquid medium, concentration of intermediate in the withdrawn liquid medium and, if used, concentration of at least one tracer in the withdrawn liquid medium, and wherein in element (b) adjustment is made to at least one of: (I) the absolute amount of catalytically active species and relative amounts of each of the first catalyst and second catalyst, and (II) at least one of the rate of feed and concentration of the raw material to the reaction zone as the manipulative inputs.

4. The method of claim 1 or 3 wherein at least one of the first catalyst and the second catalyst arc homogeneous.

5. The method of claim 1 or 3 wherein the reaction zone comprises two vessels in flow sequence.

6. The method of claim 1 or 3 wherein the adjustment of the absolute amount of catalytically active species of at least one of the catalysts is by addition of an additional amount of said catalyst to

the reaction zone.

7. The method of claim 1 or 3 wherein the adjustment of the absolute amount of catalytically active species of at least one of the catalysts is by modulating the effectiveness of the catalyst in the reaction zone.

8. The method of claim 1 or 3 wherein the reaction zone is a single pot reaction zone.

9. The method of claim 1 or 3 wherein the concentration of at least one of 1,2-butane diol, propylene glycol, at least one itol, hydroxyacetone, pH and tracer in the withdrawn medium are used to reflect performances of the catalysts.

10. The method of claim 9 wherein the itol is one or more of erythritol, threitol, glycerin, mannitol, and sorbitol.

11. The method of claim 1 or 3 wherein 1,2-butane diol, propylene glycol, at least one itol, hydroxyacetone, pH and tracer in the withdrawn medium are used to reflect performances of the catalysts.

12. The method of claim 11 wherein the itol is one or more of erythritol, threitol, glycerin, mannitol, and sorbitol.