CLAIMS

1. A hydrogentation process for producing cyclohexanone from a mixed feed comprising:

(a-1) during a first period of time, continuously providing hydrogen and hydrogenation feed comprising phenol, cyclohexanone, and cyclohexylbenzene to a hydrogenation reaction zone in which a hydrogenation catalyst bed is disposed, thereby maintaining a reaction medium flowing through the hydrogenation catalyst bed within the hydrogenation reaction zone;

(a-2) during the first period of time, maintaining initial temperature and initial pressure conditions within the hydrogenation reaction zone such that the reaction medium is entirely in vapor phase during the first period of time;

(b) adjusting the initial temperature conditions, the initial pressure conditions, or both, within the hydrogenation reaction zone to obtain liquid washing temperature and pressure conditions within the hydrogenation reaction zone, such that the reaction medium is in mixed liquid and vapor phase after the adjusting; and

(c) during a second period of time subsequent to the first period of time, maintaining the liquid washing temperature and pressure conditions within the hydrogenation reaction zone while continuously providing the hydrogen and the hydrogenation feed to the hydrogenation reaction zone, thereby maintaining the reaction medium flowing through the hydrogenation catalyst bed in mixed liquid and vapor phase.

2. The process of claim 1, further comprising:

(d) adjusting the liquid washing temperature conditions, the liquid washing pressure conditions, or both, so as to return to the initial temperature and pressure conditions within the hydrogenation reaction zone; and

(e) during a third period of time subsequent to the second period of time, maintaining the initial temperature and pressure conditions within the hydrogenation reaction zone while continuously providing the hydrogen and the hydrogenation feed to the hydrogenation reaction zone, thereby maintaining the reaction medium flowing through the hydrogenation catalyst bed entirely in vapor phase.

3. The process of claim 1 or claim 2, wherein the initial temperature and pressure conditions comprise temperature within the range of 140°C to 300°C and pressure within the range of 0 kPag to 2000 kPag; and further wherein the liquid washing temperature and pressure conditions comprise temperature within the range of 25°C to 250°C and pressure within the range of 0 kPag to 2000 kPag.

4. The process of any one of the foregoing claims, wherein, during at least a portion of the second period of time, liquid holdup within the hydrogenation reaction zone is maintained at greater than or equal to 1 vol%, based upon the available void volume in the hydrogenation catalyst bed.

5. The process of any one of the foregoing claims, wherein, during at least a portion of the second period of time, liquid mass flux through the hydrogenation catalyst bed is at least 2 kg/m^2s.

6. The process of any one of the foregoing claims, wherein the hydrogenation reaction zone comprises a shell-and-tubes heat exchange reactor, and further wherein the hydrogenation catalyst bed is disposed within one or more tubes of the shell-and-tubes heat exchange reactor.

7. The process of claim 6, wherein the adjusting (b) comprises adjusting the temperature, the flow rate, or both, of a heat exchange fluid flowing through the shell and around the tubes of the shell-and-tubes heat exchange reactor.

8. The process of any one of the foregoing claims, wherein the hydrogenation catalyst bed’s activity declines during the first period of time, and further wherein the adjusting (b) and the maintaining (c) restore at least a portion of the activity of the hydrogenation catalyst bed.

9. The process of any one of the foregoing claims, wherein the hydrogenation feed continuously provided to the hydrogenation reaction zone during the first and second time periods is obtained from cleavage reaction product, and further wherein the cleavage reaction product is obtained from a process comprising:

(1) hydroalkylating benzene and hydrogen to obtain cyclohexylbenzene;

(2) oxidizing at least a portion of the cyclohexylbenzene to obtain cyclohexylbenzene-hydroperoxide; and

(3) cleaving at least a portion of the cyclohexylbenzene-hydroperoxide to obtain the cleavage reaction product comprising phenol, cyclohexanone, and cyclohexylbenzene.

10. The process of claim 9, wherein the hydrogenation feed, prior to being continuously provided to the hydrogenation reaction zone, has been subjected to one or more pre-hydrogenation treatments selected from the group consisting of: (i) contacting the hydrogenation feed with one or more posterior sorbents; (ii) contacting the hydrogenation feed with one or more posterior distillation columns; (iii) adding to the hydrogenation feed a basic chemical agent selected from the group consisting of amines, inorganic bases, and mixtures thereof; and (iv) adding water to the hydrogenation feed such that, upon being provided to the hydrogenation reaction zone, water is present in the hydrogenation feed in an amount ranging from 0.1 wt% to 20 wt%, based on the weight of the hydrogenation feed.

11. A process comprising:

(a) during a first period of time, flowing (i) hydrogen and (ii) a vapor-phase hydrogenation feed comprising phenol, cyclohexanone, and cyclohexylbenzene through a hydrogenation catalyst bed so as to hydrogenate at least a portion of the phenol in the vapor-phase hydrogenation feed to cyclohexanone, and further so as to form one or more hydrocarbon and/or oxygenate impurities that adsorb or absorb onto at least a portion of the hydrogenation catalyst bed; and

(b) during a second period of time subsequent to the first period of time, flowing (i) hydrogen and (ii) a mixed liquid- and vapor-phase hydrogenation feed comprising phenol, cyclohexanone, and cyclohexylbenzene through the hydrogenation catalyst bed so as to hydrogenate at least a portion of the phenol in the mixed liquid- and vapor-phase hydrogenation feed to cyclohexanone, and further so as to remove at least a portion of the one or more hydrocarbon and/or oxygenate impurities from the hydrogenation catalyst bed.

12. The process of claim 11, further comprising:

(c) during a third period of time subsequent to the second period of time, flowing (i) hydrogen and (ii) additional vapor-phase hydrogenation feed comprising phenol, cyclohexanone, and cyclohexylbenzene through the hydrogenation catalyst bed so as to hydrogenate at least a portion of the phenol in the additional vapor-phase hydrogenation feed to cyclohexanone.

13. The process of claim 11 or claim 12, wherein both the vapor-phase hydrogenation feed and the mixed liquid- and vapor-phase hydrogenation feed are provided to a hydrogenation reaction zone in which the hydrogenation catalyst bed is disposed, and further wherein:

(a-1) during the first period of time, the temperature in the hydrogenation reaction zone is maintained within the range of 100°C to 300°C, and the pressure in the hydrogenation reaction zone is maintained within the range of 0 kPag to 2000 kPag; and

(b-1) during the second period of time, the temperature in the hydrogenation reaction zone is maintained within the range of 25°C to 250°C, and the pressure in the hydrogenation reaction zone is maintained within the range of 0 kPag to 2000 kPag.

14. The process of any one of claims 11 to 13, wherein, during at least a portion of the second period of time, liquid mass flux through the hydrogenation catalyst bed is at least 2 kg/m^2s.

15. The process of claim 13, wherein, during at least a portion of the second period of time, liquid holdup within the hydrogenation reaction zone is maintained at greater than or equal to 1 vol%, based upon the available void volume in the hydrogenation catalyst bed.

16. The process of claim 13, wherein the hydrogenation reaction zone comprises a shell-and-tubes heat exchange reactor, and further wherein the hydrogenation catalyst bed is disposed within one or more tubes of the shell-and-tubes heat exchange reactor.

17. The process of any one of claims 11 to 16, wherein the formation of the one or more hydrocarbon and/or oxygenate impurities decreases activity of the hydrogenation catalyst bed; and further wherein removal of at least a portion of the hydrocarbon and/or oxygenate impurities from the hydrogenation catalyst bed restores at least a portion of the hydrogenation catalyst bed's activity.

18. The process of any one of claims 11 to 17, wherein the vapor-phase hydrogenation feed and the mixed liquid- and vapor-phase hydrogenation feed are obtained from a cleavage reaction product, wherein the cleavage reaction product is obtained from a process comprising:

(1) hydroalkylating benzene and hydrogen to obtain cyclohexylbenzene;

(2) oxidizing at least a portion of the cyclohexylbenzene to obtain cyclohexylbenzene-hydroperoxide; and

(3) cleaving at least a portion of the cyclohexylbenzene-hydroperoxide to obtain the cleavage reaction product comprising phenol, cyclohexanone, and cyclohexylbenzene.

19. The process of claim 18, wherein, prior to being flowed through the hydrogenation catalyst bed, each of the vapor-phase hydrogenation feed and the mixed liquid- and vapor-phase hydrogenation feed has been subjected to one or more pre-hydrogenation treatments selected from the group consisting of: (i) contacting the hydrogenation feed with one or more posterior sorbents; (ii) contacting the hydrogenation feed with one or more posterior distillation columns; (iii) adding to the hydrogenation feed a basic chemical agent selected from the group consisting of amines, inorganic bases, and mixtures thereof; and (iv) adding water to the hydrogenation feed such that, upon being provided to the hydrogenation reaction zone, water is present in the hydrogenation feed in an amount ranging from 0.1 wt% to 20 wt%, based on the weight of the hydrogenation feed.