CLAIMS

We claim:

1. A hydrogenation process comprising:

(I) contacting a first composition with hydrogen in the presence of an eggshell hydrogenation catalyst comprising at least one metal component selected from Groups 6 to 10 of the Periodic Table of Elements and at least one support, such that more than 50 wt% of the at least one metal component present in the hydrogenation catalyst is deposited in a peripheral outer layer of the support,

wherein the first composition comprises:

(i) greater than about 25 wt% of cyclohexylbenzene, the wt% based upon the total weight of the first composition; and

(ii) greater than about 0.05 wt% in total of ~~cyclohexylbenzene~~ cyclohexenylbenzene, the wt% based upon the total weight of the first composition, and

thereby obtaining a second composition having a lower concentration of the ~~cyclohexylbenzene~~ cyclohexenylbenzene in total than the first composition.

2. The process of claim 1, wherein in the contacting step (I), at least a portion of the cyclohexenylbenzene is converted into cyclohexylbenzene.

3. The process of claim 2, wherein in the contacting step (I), the selectivity of the conversion of cyclohexenylbenzene to cyclohexylbenzene is SC1, the selectivity of the conversion of cyclohexenylbenzene to bicyclohexane is SC2, and (SC1-SC2)/SC1 $\geqslant$ 0.50.

~~5.~~4. The process of claim 1 or claim 2,

wherein the second composition optionally comprises bicyclohexane such that the concentration of bicyclohexane in the second composition, expressed in terms of weight percentage of the total weight of the second composition, is CON(BCH)(2), and the first composition optionally comprises bicyclohexane such that the concentration of bicyclohexane in the first composition, expressed in terms of weight percentage of the total weight of the first composition, is CON(BCH)(1), and

further wherein CON(BCH)(2) – CON(BCH)(1) $\leqslant$ 0.50%.

5. The process of any of the preceding claims, wherein the contacting step (I) is conducted at a temperature in a range from about 40°C to about 200°C and a pressure in the range from 700 kPa to 1000 kPa.

6. The process of any one of the preceding claims, wherein the at least one metal component comprises palladium, cobalt, nickel, ruthenium, or a mixture of two or more thereof.

7. The process of any one of the preceding claims, wherein the support comprises at least one of aluminum oxide, silica, silicate, aluminosilicate, carbon, carbon nanotubes, and a mixture of two or more thereof.

8. The process of any one of the preceding claims, wherein the eggshell hydrogenation catalyst comprises about 0.1 wt% to about 10 wt% of the metal component, the wt% based upon the total weight of the eggshell hydrogenation catalyst including the metal and the support.

9. A process for producing phenol and/or cyclohexanone, the process comprising:

(A) contacting a first feed comprising benzene with hydrogen in the presence of a hydroalkylation catalyst to produce a first effluent stream comprising cylcohexylbenzene and cyclohexenyl benzene;

(B) oxidizing a second feed comprising at least a portion of the cylcohexylbenzene present in the first effluent stream to produce a second effluent stream comprising cyclohexylbenzene hydroperoxide;

(C) cleaving a third feed comprising at least a portion of the cyclohexylbenzene hydroperoxide in the second effluent stream to produce a third effluent stream comprising phenol, cyclohexanone and cyclohexenylbenzene; and

(D) contacting a fourth feed comprising at least a portion of the cyclohexenylbenzene in the first effluent stream and/or the third effluent stream with hydrogen in the presence of an eggshell hydrogenation catalyst to produce a fourth effluent stream comprising cyclohexylbenzene;

wherein the eggshell hydrogenation catalyst comprises at least one metal component selected from Groups 6 to 10 of the Periodic Table of Elements and at least one support, such that more than 50 wt% of the at least one metal component present in the hydrogenation catalyst is deposited in a peripheral outer layer of the support.

10. The process of claim 9, wherein at least a portion of the cyclohexylbenzene in the fourth effluent stream is provided into the second feed of the oxidizing step (B).

11. The process of claim 9 or claim 10, wherein in the contacting step (D), the fourth feed comprises at least a portion of the cyclohexenylbenzene in both of the first effluent stream and the third effluent stream.

12. The process of any of claims 9 to 11, wherein in the oxidizing step (B), the second feed has a concentration of cyclohexenylbenzene of at most 0.05 wt% of the total weight of the second feed.

13. A process for producing phenol and/or cyclohexanone, the process comprising:

(a) reacting benzene with hydrogen in the presence of a hydroalkylation catalyst under conditions effective to produce a hydroalkylation reaction effluent comprising cyclohexylbenzene and olefinic byproducts, benzene, and hydrogen;

(b) removing a purge stream from the hydroalkylation reaction effluent, said purge stream comprising hydrogen and benzene;

(c) washing the purge stream with a further stream containing cyclohexylbenzene to produce a benzene-depleted purge gas stream containing hydrogen and a wash stream containing cyclohexylbenzene and benzene;

(d) separating an impure product stream comprising cyclohexylbenzene and olefinic byproducts from the hydroalkylation reaction effluent in the reacting step (a);

(e) contacting the impure product stream of the separating step (d) with the benzene-depleted purge gas stream in the presence of an eggshell hydrogenation catalyst under conditions such that hydrogen in the benzene-depleted purge gas stream reacts with the olefinic by-products to produce a hydrogenated product stream and a hydrogen-depleted purge gas stream;

wherein the eggshell hydrogenation catalyst comprises at least one metal component selected from Groups 6 to 10 of the Periodic Table of Elements and at least one support, such that more than 50 wt% of the at least one metal component present in the hydrogenation catalyst is deposited in a peripheral outer layer of the support;

(f) purging said hydrogen-depleted purge gas stream;

(g) oxidizing at least a portion of the cyclohexylbenzene in said hydrogenated product stream of the contacting step (e) to cyclohexylbenzene hydroperoxide; and

(h) cleaving at least a portion of the cyclohexylbenzene hydroperoxide produced in (g) to produce a cleavage product stream comprising phenol and cyclohexanone.

14. The process of claim 13, wherein the wash stream in the washing step (c) is recycled to the separating step (d).

15. The process of claim 13 or claim 14, wherein the cleavage product stream in the cleaving step (h) comprises cyclohexenylbenzene.

16. The process of any of claims 13 to 15, wherein the cyclohexenylbenzene from the cleavage product stream in the cleaving step (h) is recycled to the contacting step (e) and into the impure product stream of the contacting step (e).

17. The process of any of claims 13 to 15, wherein the impure product stream in the contacting step (e) contains greater than 0.10 wt% of olefinic byproducts from the hydroalkylation, oxidation, and/or cleavage reaction effluents.

18. The process of any of claims 13 to 17, wherein the eggshell hydrogenation catalyst comprises about 0.10 wt% to about 10.0 wt% of the at least one metal component, the wt% based upon the total weight of the hydrogenation catalyst including the metal component and the support.

19. A process for producing phenol and/or cyclohexanone, the process comprising:

(a) reacting benzene with hydrogen in the presence of a hydroalkylation catalyst under conditions effective to produce a hydroalkylation reaction effluent comprising

cyclohexylbenzene and olefinic byproducts;

(b) removing a purge stream from the hydroalkylation reaction effluent, said purge stream comprising hydrogen and benzene;

(c) washing the purge stream with a further stream containing cyclohexylbenzene to produce a benzene-depleted purge gas stream containing hydrogen and a wash stream containing cyclohexylbenzene and benzene;

(d) separating an impure product stream comprising cyclohexylbenzene and at least a portion of the olefinic byproducts from the hydroalkylation reaction effluent;

(e) contacting the impure product stream with the benzene-depleted purge gas stream in the presence of a hydrogenation catalyst under conditions such that hydrogen in the benzene-depleted purge gas stream reacts with the olefinic byproducts to produce a hydrogenated product stream and a hydrogen-depleted purge gas stream;

(f) purging said hydrogen-depleted purge gas stream;

(g) oxidizing at least a portion of the cyclohexylbenzene in the hydrogenated product stream to cyclohexylbenzene hydroperoxide;

(h) cleaving at least a portion of the cyclohexylbenzene hydroperoxide produced in (g) to produce a cleavage product stream comprising phenol, cyclohexenylbenzene, and cyclohexanone;

(i) separating out a product stream comprising phenol and cyclohexanone and a recycle stream comprising cyclohexenylbenzene and residual cyclohexylbenzene; and

(j) contacting the recycle stream with a gas stream comprising hydrogen in the presence of an eggshell hydrogenation catalyst under conditions such that hydrogen in the gas stream reacts with cyclohexenylbenzene to produce a hydrogenated recycle stream comprising cyclohexylbenzene and a hydrogen-depleted gas stream;

wherein the eggshell hydrogenation catalyst comprises at least one metal component selected from Groups 6 to 10 of the Periodic Table of Elements and at least one support, such that more than 50 wt% of the at least one metal component present in the hydrogenation catalyst is deposited in a peripheral outer layer of the support.

20. The process of claim 19, wherein the selectivity of the conversion of cyclohexenylbenzene to cyclohexylbenzene is SC1, the selectivity of the conversion of cyclohexenylbenzene to bicyclohexane is SC2, and (SC1-SC2)/SC1 $\geqslant$ 0.50.

21. The process of claim 19 or claim 20, wherein the impure product stream contains greater than 1.0 wt% of the olefinic byproducts from the hydroalkylation reaction effluent.

22. The process of any of claims 19 to 21, wherein the hydrogenation catalyst of the contacting step (e) and/or the eggshell hydrogenation catalyst of the contacting step (j) comprise from about 0.1 wt% to about 10 wt% of a metal component selected from palladium, cobalt, nickel, ruthenium, or a mixture of two or more thereof, the wt% based upon the total weight of the hydrogenation catalyst including the metal components and the support.