CLAIMS

What is claimed:

1. A process for producing C5 olefins from a steam cracker C5 feed, the process comprising:

   reacting a mixed hydrocarbon stream comprising cyclopentadiene, linear C5 olefins, cyclic C5 olefins, and C6+ hydrocarbons wherein cyclopentadiene is dimerized to form dicyclopentadiene;

   separating the reacted mixture to form a first fraction comprising the C6+ hydrocarbons and dicyclopentadiene and a second fraction comprising the linear and cyclic C5 olefins and C5 dienes;

   feeding the second fraction and hydrogen to a catalytic distillation reactor system, wherein the second fraction is introduced intermediate a first catalyst zone and a second catalyst zone;

   concurrently in the catalytic distillation reactor system:

      separating the linear C5 olefins from the cyclic C5 olefins and C5 dienes contained in the second fraction; and

      selectively hydrogenating at least a portion of the C5 dienes to form additional C5 olefins; and

   recovering an overhead distillate including the linear C5 olefins from the catalytic distillation reactor system;

   recovering a bottoms product including cyclic C5 olefins from the catalytic distillation reactor system;

   feeding a saturated hydrocarbon diluent to the catalytic distillation reactor system;

   determining a concentration of the saturated hydrocarbon diluent at one or more column elevations; and

   adjusting one or more column parameters to maintain a set point concentration or a concentration profile of the saturated hydrocarbon diluent at the one or more column elevations.

2. The process of claim 1, wherein the steps of reacting the mixed hydrocarbon stream and separating the reacted mixture are performed concurrently in a low temperature / low pressure distillation column, reacting the cyclopentadiene to form a dimerized product comprising dicyclopentadiene, and fractionating the mixed hydrocarbon stream to form the first fraction comprising the C6+ hydrocarbons and

dicyclopentadiene and the second fraction comprising the linear and cyclic C5 olefins and C5 dienes.

3. The process of claim 2, further comprising operating the low temperature / low pressure distillation column in liquid continuous distillation operation.
4. The process of claim 2, wherein an average residence time in the low temperature / low pressure distillation column is in the range from 0.2 hours to 6 hours.
5. The process of claim 4, wherein the average residence time is sufficient to allow for greater than 90 wt% of the cyclopentadiene to dimerize.
6. The process of claim 2, further comprising operating the low temperature / low pressure distillation column at a pressure in the range from about 15 psia to about 85 psia, at an overhead condenser temperature in the range from about 90°F to about 150°F and at a reboiler temperature in the range from about 155°F to 300°F.
7. The process of claim 1, further comprising:

   purging a portion of the bottoms product;

   reacting a remaining portion of the bottoms product in a total hydrogenation unit to convert the cyclic C5 olefins to cyclopentane; and

   recycling the cyclopentane to the catalytic distillation reactor system as the saturated hydrocarbon diluent.
8. The process of claim 1, wherein the saturated hydrocarbon diluent comprises one or more hydrocarbons having a normal boiling point of at least 102.5°F.
9. The process of claim 1, further comprising feeding the overhead distillate from the catalytic distillation reactor system to a metathesis unit and converting the linear C5 olefins to propylene.
10. The process of claim 1, wherein the overhead distillate comprises less than 2.5 wt% cyclopentene and wherein the second fraction comprises less than 0.5 wt% benzene.
11. The process of claim 1, wherein an olefin recovery, measured as moles linear and branched C5 olefins in the overhead distillate divided by moles linear and branched C5 olefins and dienes in the mixed hydrocarbon stream, is greater than 83%.
12. The process of claim 7, wherein the reacting step is performed in a dimerization reactor and the separating the reacted mixture is performed in a fractionator, the process further comprising:

    operating the dimerization reactor at a pressure in the range from about 130 psia to about 170 psia and a temperature in the range from about 210°F to about 250°F;

operating the fractionator at a pressure in the range from about 15 psia to about 85 psia and at a condenser temperature in the range from about 97°F and 213°F;

operating the catalytic distillation reactor system at a pressure in the range from about 60 psia to about 240 psia and a reboiler temperature in the range from 220°F and 320°F, and a hydrogen partial pressure in the range from about 1 psi to about 25 psia; and

operating the total hydrogenation unit at a pressure in the range from about 220 psia to about 300 psia and at a temperature in the range from about 200°F and 260°F.

13. The process of claim 1, further comprising partially vaporizing the second fraction prior to introducing the second fraction to the catalytic distillation reactor system, wherein the partial vaporizer is operated at conditions sufficient to vaporize between 5 wt% and 95 wt% of the C5 dienes.
14. The process of claim 1, further comprising separating the overhead distillate to recover a product fraction comprising linear C5 olefins and a recycle fraction comprising cyclopentene.
15. The process of claim 1, wherein the catalytic distillation reactor system has at least three reaction zones, including: (a) a first reaction zone disposed below a C5-olefin containing stream feed elevation and containing a nickel-based catalyst; (b) a second reaction zone disposed above the C5-olefin containing stream feed elevation and containing a nickel-based catalyst; and (c) a third reaction zone disposed above the second reaction zone and containing a palladium-based catalyst.
16. The process of claim 15, wherein the nickel-based catalyst comprises from about 5 wt% to about 30 wt% nickel.
17. The process of claim 16, wherein the nickel-based catalyst is disposed on a diatomaceous earth support, has a BET surface area in the range from about 20 m^2/g to about 400 m^2/g, and has a pore volume in the range from about 0.2 ml/g to about 0.7 ml/g.
18. The process of claim 15, wherein the palladium-based catalyst comprises from about 0.2 to about 1.0 wt% palladium disposed on an alumina support.

19. The process of claim 1, further comprising:

determining a density of a liquid fraction at one or more elevations of the catalytic distillation reactor system; and

adjusting one or more catalytic distillation reactor system operating parameters to maintain a set point density or density profile at the one or more elevations.

20. A process for producing C5 olefins from a steam cracker C5 feed, the process comprising:

reacting a mixed hydrocarbon stream comprising cyclopentadiene, linear C5 olefins, cyclic C5 olefins, and C6+ hydrocarbons in a dimerization reactor wherein cyclopentadiene is dimerized to form dicyclopentadiene, producing a dimerization reactor effluent;

separating the dimerization reactor effluent in a fractionator to form a first fraction comprising the C6+ hydrocarbons and dicyclopentadiene and a second fraction comprising the linear and cyclic C5 olefins and linear C5 dienes;

feeding the second fraction, a saturated hydrocarbon diluent stream, and hydrogen to a catalytic distillation reactor system, wherein the second fraction is introduced below a first catalyst zone;

concurrently in the catalytic distillation reactor system:

separating the linear C5 olefins from the saturated hydrocarbon diluent, the cyclic C5 olefins, and linear C5 dienes contained in the second fraction; and

selectively hydrogenating at least a portion of the C5 dienes to form additional linear C5 olefins; and

recovering linear C5 olefins in an overhead distillate from the catalytic distillation reactor system;

recovering cyclic C5 olefins in a bottoms product from the catalytic distillation reactor system;

feeding a saturated hydrocarbon diluent to the catalytic distillation reactor system;

determining a concentration of the saturated hydrocarbon diluent at one or more column elevations; and

adjusting one or more column parameters to maintain a set point concentration or a concentration profile of the saturated hydrocarbon diluent at the one or more column elevations.

21. The process of claim 20, further comprising

purging a portion of the bottoms product;

reacting a remaining portion of the bottoms product in a total hydrogenation unit to convert the cyclic C5 olefins to cyclopentane; and

recycling the cyclopentane to the catalytic distillation reactor system as the saturated hydrocarbon diluent.

22. The process of claim 20, further comprising feeding the second fraction to a fixed bed selective hydrogenation unit to selectively hydrogenate C5 dienes prior to feeding the second fraction to the catalytic distillation reactor system.

23. The process of claim 20, further comprising partially vaporizing the second fraction prior to introducing the second fraction to the catalytic distillation reactor system.

24. The process of claim 20, further comprising separating the overhead distillate to recover a product fraction comprising linear C5 olefins and a recycle fraction comprising cyclopentene.

25. A process for producing C5 olefins from a steam cracker C5 feed, the process comprising:

feeding a mixed hydrocarbon stream comprising cyclopentadiene, linear C5 olefins, cyclic C5 olefins, C5 dienes, and C6+ hydrocarbons to a low temperature / low pressure distillation column;

concurrently in the low temperature / low pressure distillation column:

reacting the cyclopentadiene to form a dimerized product comprising dicyclopentadiene;

fractionating the mixed hydrocarbon stream to form a first fraction comprising the C6+ hydrocarbons and dicyclopentadiene and a second fraction comprising the linear and cyclic C5 olefins and C5 dienes;

feeding the second fraction and hydrogen to a catalytic distillation reactor system, wherein the second fraction is introduced intermediate a first catalyst zone and a second catalyst zone;

concurrently in the catalytic distillation reactor system:

separating the linear C5 olefins from the cyclic C5 olefins and C5 dienes contained in the second fraction; and

selectively hydrogenating at least a portion of the C5 dienes to form additional C5 olefins; and

recovering an overhead distillate comprising the linear C5 olefins from the catalytic distillation reactor system;

recovering a bottoms product comprising cyclic C5 olefins from the catalytic distillation reactor system;

feeding a saturated hydrocarbon diluent to the catalytic distillation reactor system;

determining a concentration of the saturated hydrocarbon diluent at one or more column elevations; and

adjusting one or more column parameters to maintain a set point concentration or a concentration profile of the saturated hydrocarbon diluent at the one or more column elevations.

26. The process of claim 25, further comprising operating the low temperature / low pressure distillation column in liquid continuous distillation operation.
27. The process of claim 25, wherein a saturated hydrocarbon diluent stream is co-fed with the second fraction and hydrogen to the catalytic distillation reactor system.
28. The process of claim 25, wherein an average residence time in the low temperature / low pressure distillation column is in the range from 0.2 hours to 6 hours.
29. The process of claim 25, wherein the residence time is sufficient to allow for greater than 90 wt% of the cyclopentadiene to dimerize.
30. The process of claim 1, further comprising operating the low temperature / low pressure distillation column at a pressure in the range from about 15 psia to about 85 psia, an overhead condenser temperature in the range from about 90°F to about 150°F, and at a reboiler temperature in the range from about 155°F to 300°F.