CLAIMS

1. A process for producing raw materials for producing truly circular polymers, the process comprising:

   processing a waste plastic pyrolysis oil in a first reactor system with a catalyst mixture;

   processing a fossil-based feedstock in a second reactor system with the catalyst mixture;

   supplying the catalyst mixture to each of the first and second reactor systems from a common catalyst regenerator;

   recovering an effluent comprising fossil-based hydrocarbon products from the second reactor system;

   recovering an effluent comprising waste-derived hydrocarbon products from the first reactor system; and

   returning spent catalyst from each of the first and second reactor systems to the common catalyst regenerator;

   wherein the spent catalyst from the second reactor system comprises both of:

      an additive type cracking catalyst or a mixture of additive type cracking catalysts selected from the group consisting of Medium Pore Zeolites and pentasil family zeolites; and

      a contaminant trapping additive or a mixture of contaminant trapping additives selected from the group consisting of MgO, CaO, CeO_2, $MgTiO_3$, $CaTiO_3$, $Li_2Ti_2O_7$ and $ZnTiO_3$, Ca/Mg, boron, a rare earth-based trapping additives, or a low chlorine FCC catalyst.

2. The process of claim 1, further comprising maintaining the fossil-based hydrocarbon products recovered from the second reactor system separate from the waste-derived hydrocarbon products recovered from the first reactor system.

3. The process of claim 2, further comprising feeding an olefin fraction recovered from the waste-derived hydrocarbon products to a polymerization system to produce circular polymers.

4. The process of any one of claims 1-3, further comprising pyrolyzing a waste stream comprising plastics, tires, or other polymeric materials to produce the waste plastic pyrolysis oil.

5. The process of any one of claims 1-4, further comprising directly or indirectly feeding one or more of the waste-derived hydrocarbon products, or a waste-derived monomer resulting from processing of the waste-derived hydrocarbon products, to a polymerization process to produce a circular polymer.
6. A process for converting waste plastics to feedstock to produce plastics, the process comprising:

pyrolyzing a waste polymeric feedstock to produce a waste plastic pyrolysis oil;

regenerating a catalyst mixture in a catalyst regenerator, the catalyst mixture comprising a first catalyst and a second catalyst;

feeding a portion of the catalyst mixture to a first reactor system;

feeding a portion of the catalyst mixture to a second reactor system;

in the first reactor system, contacting a fossil-based feedstock with the catalyst mixture to crack a portion of the fossil-based feedstock to produce a first effluent comprising fossil-derived olefins, first catalyst, and second catalyst;

in the second reactor system:

contacting the waste plastic pyrolysis oil with a concentrated catalyst mixture in a reactor to crack a portion of the waste plastic pyrolysis oil, wherein the concentrated catalyst mixture comprises the portion of the catalyst mixture fed to the second reactor system and additional second catalyst, the catalyst mixture in the second reactor system thus having a higher concentration of second catalyst than in the catalyst regenerator or the first reactor system, and wherein the contacting produces a second reactor effluent comprising waste-derived olefins and other hydrocarbons, the first catalyst, and the second catalyst;

separating the second reactor effluent to produce a first stream, comprising the first catalyst and the waste-derived olefins and other hydrocarbons, and a second stream, comprising the second catalyst;

feeding the second stream, as the additional second catalyst, to the second reactor system, thereby concentrating the second catalyst within the second reactor system;

separating the first effluent to recover (i) a mixture of spent first catalyst and spent second catalyst and (ii) a first reactor system product stream comprising the fossil-derived olefins;

wherein the spent catalyst from the second reactor system comprises both of:

an additive type cracking catalyst or a mixture of additive type cracking catalysts selected from the group consisting of Medium Pore Zeolites and pentasil family zeolites; and

a contaminant trapping additive or a mixture of contaminant trapping additives selected from the group consisting of MgO, CaO, CeO_2, $MgTiO_3$, $CaTiO_3$, $Li_2Ti_2O_7$ and $ZnTiO_3$, Ca/Mg, boron, a rare earth-based trapping additives, or a low chlorine FCC catalyst;

separating the first stream to recover (i) spent first catalyst and (ii) a second reactor system product stream comprising the waste-derived olefins and other waste-derived hydrocarbons; and

feeding to the catalyst regenerator each of (i) the mixture of spent first catalyst and spent second catalyst and (ii) the spent first catalyst.

7. The process of claim 6, wherein the first catalyst comprises one or more selected from the group consisting of amorphous silica alumina, Y-type zeolites, X-type zeolites, zeolite Beta, zeolite MOR, mordenite, faujasite, nano-crystalline zeolites, and MCM mesoporous material.
8. The process of claim 6 or claim 7, further comprising:

feeding the first reactor system product stream to a first fractionation system to separate the first reactor system product stream to recover two or more fossil-derived hydrocarbon fractions; and

feeding the second reactor system product stream to a second fractionation system to separate the second reactor system product stream to recover two or more waste-derived hydrocarbon fractions.

9. The process of claim 8, further comprising directly or indirectly feeding one or more of the two or more waste-derived hydrocarbon fractions, or a monomer resulting from processing of one or more of the two or more waste-derived hydrocarbon fractions, to a polymerization process to produce a circular polymer.
10. The process for converting waste plastics to feedstock to produce plastics as claimed in any one of claims 6 to 9, wherein:

the pyrolyzing comprises pyrolyzing a waste polymeric feedstock to produce a waste plastic pyrolysis oil having a concentration of one or more contaminants selected

from the group consisting of iron, calcium, copper, potassium, magnesium, sodium, silicon, titanium, zinc and chlorine;

the catalyst mixture comprising a first catalyst and a second catalyst comprises a second catalyst configured to trap the one or more contaminants;

the contacting in the second reactor system comprises:

contacting the waste plastic pyrolysis oil with a concentrated catalyst mixture in a first stage reactor to remove contaminants from the waste plastic pyrolysis oil and to crack a portion of the waste plastic pyrolysis oil, wherein the concentrated catalyst mixture comprises the portion of the catalyst mixture fed to the second reactor system and additional second catalyst, the catalyst mixture in the first stage reactor thus having a higher concentration of second catalyst than in the catalyst regenerator, and wherein the contacting produces a first stage reactor effluent comprising a treated waste plastic pyrolysis oil having a reduced contaminant concentration, the first catalyst, and the second catalyst containing trapped contaminants;

separating the first stage reactor effluent to produce a first stream, comprising the first catalyst and the treated waste plastic pyrolysis oil having a reduced contaminant concentration, and a second stream, comprising the second catalyst;

feeding the second stream, as the additional second catalyst, to the first stage reactor, thereby concentrating the second catalyst within the first stage reactor; and

feeding the first stream to a second stage reactor to crack the treated waste plastic pyrolysis oil to recover a second stage reactor effluent comprising spent catalyst and waste-derived olefins and other waste-derived hydrocarbons; and

wherein separating the first stream to recover (i) spent first catalyst and (ii) a second reactor system product stream comprises separating the second stage reactor effluent to recover (i) spent first catalyst and (ii) a second reactor system product stream comprising the waste-derived olefins and other waste-derived hydrocarbons.

11. The process of claim 10, further comprising maintaining the fossil-derived hydrocarbon fractions recovered from the first reactor system separate from the waste-derived hydrocarbon fractions recovered from the second reactor system.

12. The process of claim 10, further comprising feeding one or more hydrocarbon fractions recovered from the waste-derived hydrocarbon fractions to a first reactor of the second reactor system.
13. The process of claim 10, further comprising feeding one or more hydrocarbon fractions recovered from the waste-derived hydrocarbon fractions to a second reactor of the second reactor system.
14. The process of claim 10, further comprising withdrawing a portion of the second catalyst from a first reactor of the second reactor system.
15. A process for converting waste plastic materials into monomers for production of circular polymers, the process comprising:

pyrolyzing a waste polymeric feedstock to produce a waste plastic pyrolysis oil having a concentration of one or more contaminants selected from the group consisting of iron, calcium, copper, potassium, magnesium, sodium, silicon, titanium, zinc and chlorine;

regenerating a catalyst mixture in a catalyst regenerator, the catalyst mixture comprising a first catalyst and a second catalyst, wherein the second catalyst is configured to trap the one or more contaminants;

feeding a portion of the catalyst mixture to a first reactor system;

feeding a portion of the catalyst mixture to a second reactor system;

in the first reactor system:

contacting the waste plastic pyrolysis oil with a concentrated catalyst mixture in a first reactor to remove contaminants from the waste plastic pyrolysis oil and to crack a portion of the waste plastic pyrolysis oil, wherein the concentrated catalyst mixture comprises the portion of the catalyst mixture fed to the first reactor system and additional second catalyst, the catalyst mixture in the first reactor system thus having a higher concentration of second catalyst than in the catalyst regenerator, and wherein the contacting produces a first reactor effluent comprising a treated waste plastic pyrolysis oil having a reduced contaminant concentration, the first catalyst, and the second catalyst containing trapped contaminants;

separating the first reactor effluent to produce a first stream, comprising the first catalyst and the treated waste plastic pyrolysis oil having a reduced

contaminant concentration, and a second stream, comprising the second catalyst;

feeding the second stream, as the additional second catalyst, to the first reactor, thereby concentrating the second catalyst within the first reactor system; and

feeding the first stream to a separation system to recover a first separation effluent comprising spent first catalyst and a second separation effluent comprising the treated waste plastic pyrolysis oil;

feeding the second separation effluent to a fractionation system to fractionate the treated waste pyrolysis oil into three or more hydrocarbon fractions, including a light olefin fraction, a naphtha fraction, and a treated pyrolysis oil fraction;

feeding at least one of the naphtha fraction and the treated pyrolysis oil fraction to a second reactor system,

in the second reactor system, contacting the at least one of the naphtha fraction and the treated pyrolysis oil fraction with the catalyst mixture to crack a portion of the hydrocarbons therein to produce a second reactor system effluent comprising waste-derived olefins, first catalyst, and second catalyst;

separating the second reactor system effluent to recover (i) a mixture of spent first catalyst and spent second catalyst and (ii) a second reactor system product stream comprising the waste-derived olefins; and

feeding to the catalyst regenerator each of (i) the mixture of spent first catalyst and spent second catalyst and (ii) the first separation effluent comprising spent first catalyst.

16. A process for producing raw materials for producing truly circular polymers, the process comprising:

processing a waste polymer mixture in a first reactor system comprising a first stage reactor and a second stage reactor, the processing of the waste polymer mixture comprising:

feeding the waste polymer mixture to the first stage reactor to pyrolyze polymers therein and to recover a pyrolyzed effluent;

feeding a waste-derived plastic pyrolysis oil and a catalyst mixture to the second stage reactor to crack hydrocarbons therein and to recover an effluent comprising cracked hydrocarbons;

feeding the pyrolyzed effluent from the first stage reactor and the effluent from the second stage reactor to a first fractionation system to separate the effluents into two or more waste-derived hydrocarbon streams including the waste-derived plastic pyrolysis oil and one or more waste-derived olefin fractions;

processing a fossil-based feedstock in a second reactor system with the catalyst mixture;

supplying the catalyst mixture to each of the first and second reactor systems from a common catalyst regenerator;

recovering an effluent comprising fossil-based hydrocarbon products from the second reactor system;

feeding the effluent comprising fossil-based hydrocarbon products to a second fractionation system; and

returning spent catalyst from each of the first and second reactor systems to the common catalyst regenerator,

wherein the spent catalyst from the second reactor system comprises both of:

an additive type cracking catalyst or a mixture of additive type cracking catalysts selected from the group consisting of Medium Pore Zeolites and pentasil family zeolites; and

a contaminant trapping additive or a mixture of contaminant trapping additives selected from the grou consisting of MgO, CaO, CeO_2, $MgTiO_3$, $CaTiO_3$, $Li_2Ti_2O_7$ and $ZnTiO_3$, Ca/Mg, boron, a rare earth-based trapping additives, or a low chlorine FCC catalyst.

17. The process of claim 16, wherein the catalyst mixture comprises a first catalyst and a second catalyst, and wherein the second stage reactor is a catalyst-concentrating reactor system, wherein the process comprises:

recovering a second stage reactor effluent comprising the catalyst mixture and the cracked hydrocarbons;

separating the second stage reactor effluent to produce a first stream, comprising the first catalyst and the cracked hydrocarbons, and a second stream, comprising the second catalyst;

separating the first stream to recover a (i) spent catalyst and (ii) the second stage reactor effluent fed to the first fractionation system; and

feeding the second stream to the second stage reactor, thereby concentrating the second catalyst circulating within the second reactor system to a concentration greater than the catalyst mixture as received from the regenerator.

18. The process according to any one of claims 1 to 17, wherein the waste-derived polymeric pyrolysis oil is derived from, or wherein the waste polymeric feedstock or waste polymer mixture comprises: one or more thermoplastics selected from the group consisting of polystyrene, polypropylene, polyphenylene sulfide, polyphenylene oxide, polyethylene, polyetherimide, polyether ether ketone, polyoxymethylene, polyether sulfone, polycarbonate, polybenzimidazole, polylactic acid, nylon, acrylonitrile-butadiene-styrene (ABS) polymers, poly methyl methacrylic acid (PMMA); one or more thermosets formed from monomers including one or more of acrylics, polyesters, vinyl esters, epoxies, urethanes, ureas, and isocyanates; and one or more unsaturated or saturated elastomers selected from the group consisting of polybutadiene, isoprene, chloroprene, styrene-butadiene, nitrile, and ethylene vinyl acetate.

19. A system for producing raw materials for producing truly circular polymers, the system comprising:

a first reactor system containing a catalyst mixture and configured for processing a waste plastic pyrolysis oil;

a second reactor system configured for processing a fossil-based feedstock with the catalyst mixture;

feed lines for supplying the catalyst mixture to each of the first and second reactor systems from a common catalyst regenerator;

a flow line for recovering an effluent comprising fossil-based hydrocarbon products from the second reactor system;

a flow line for recovering an effluent comprising waste-derived hydrocarbon products from the first reactor system; and

flow lines for returning spent catalyst from each of the first and second reactor systems to the common catalyst regenerator;

wherein the spent catalyst from the second reactor system comprises both of:

an additive type cracking catalyst or a mixture of additive type cracking catalysts selected from the group consisting of Medium Pore Zeolites and pentasil family zeolites; and

a contaminant trapping additive or a mixture of contaminant trapping additives selected from the group consisting of MgO, CaO, CeO_2, $MgTiO_3$, $CaTiO_3$, $Li_2Ti_2O_7$ and $ZnTiO_3$, Ca/Mg, boron, a rare earth-based trapping additives, or a low chlorine FCC catalyst.

20. The system of claim 19, further comprising a waste plastic pyrolysis system configured to pyrolyze a waste stream comprising plastics, tires, or other polymeric materials to produce the waste plastic pyrolysis oil.

21. A system for converting waste plastics to feedstock to produce plastics, the system comprising:

a waste plastic pyrolysis reactor system configured for pyrolyzing a waste polymeric feedstock to produce a waste plastic pyrolysis oil;

a catalyst regenerator for regenerating a catalyst mixture, the catalyst mixture comprising a first catalyst and a second catalyst;

a first flow line for feeding a portion of the catalyst mixture from the catalyst regenerator to a first reactor system;

a second flow line for feeding a portion of the catalyst mixture from the catalyst regenerator to a second reactor system;

the first reactor system, configured for contacting a fossil-based feedstock with the catalyst mixture to crack a portion of the fossil-based feedstock to produce a first effluent comprising fossil-derived olefins, first catalyst, and second catalyst;

the second reactor system, configured for:

contacting the waste plastic pyrolysis oil with a concentrated catalyst mixture in a reactor to crack a portion of the waste plastic pyrolysis oil, wherein the concentrated catalyst mixture comprises the portion of the catalyst mixture fed to the second reactor system and additional second catalyst, the catalyst mixture in the second reactor system thus having a higher concentration of second catalyst than in the catalyst regenerator or a first reactor of the second reactor system, and wherein the contacting produces a second reactor effluent comprising waste-derived olefins and other hydrocarbons, the first catalyst, and the second catalyst;

separating the second reactor effluent to produce a first stream, comprising the first catalyst and the waste-derived olefins and other hydrocarbons, and a second stream, comprising the second catalyst;

feeding the second stream, as the additional second catalyst, to a second reactor of the second reactor system, thereby concentrating the second catalyst within the second reactor system;

a first separation system for separating the first effluent to recover (i) a mixture of spent first catalyst and spent second catalyst and (ii) a first reactor system product stream comprising the fossil-derived olefins;

wherein the spent catalyst from the second reactor system comprises both of:

an additive type cracking catalyst or a mixture of additive type cracking catalysts selected from the group consisting of Medium Pore Zeolites and pentasil family zeolites; and

a contaminant trapping additive or a mixture of contaminant trapping additives selected from the group consisting of MgO, CaO, CeO_2, $MgTiO_3$, $CaTiO_3$, $Li_2Ti_2O_7$ and $ZnTiO_3$, Ca/Mg, boron, a rare earth-based trapping additives, or a low chlorine FCC catalyst;

a separation system for separating the first stream to recover (i) spent first catalyst and (ii) a second reactor system product stream comprising the waste-derived olefins and other hydrocarbons; and

flow lines configured for feeding to the catalyst regenerator each of (i) the mixture of spent first catalyst and spent second catalyst and (ii) the spent first catalyst.

22. The system of claim 21, further comprising:

a first fractionation system configured to separate the first reactor system product stream to recover two or more fossil-derived hydrocarbon fractions; and

a second fractionation system configured to separate the second reactor system product stream to recover two or more waste-derived hydrocarbon fractions.

23. The system of claim 21, further comprising a polymerization system configured to directly or indirectly receive one or more of the two or more waste-derived hydrocarbon fractions, or a monomer resulting from processing of one or more of the two or more waste-derived hydrocarbon fractions, to produce a circular polymer.

24. A system for converting waste plastics to feedstock to produce plastics, the system comprising:

a pyrolysis reactor system for pyrolyzing a waste polymeric feedstock to produce a waste plastic pyrolysis oil having a concentration of one or more contaminants selected from the group consisting of iron, calcium, copper, potassium, magnesium, sodium, silicon, titanium, zinc and chlorine;

a catalyst regenerator for regenerating a catalyst mixture, the catalyst mixture comprising a first catalyst and a second catalyst, wherein the second catalyst is configured to trap the one or more contaminants;

a flow line for feeding a portion of the catalyst mixture from the catalyst regenerator to a first reactor system;

a flow line for feeding a portion of the catalyst mixture from the catalyst regenerator to a second reactor system;

the first reactor system, configured for contacting a fossil-based feedstock with the catalyst mixture to crack a portion of the fossil-based feedstock to produce a first effluent comprising fossil-derived olefins, first catalyst, and second catalyst;

the second reactor system, configured for:

contacting the waste plastic pyrolysis oil with a concentrated catalyst mixture in a first stage reactor to remove contaminants from the waste plastic pyrolysis oil and to crack a portion of the waste plastic pyrolysis oil, wherein the concentrated catalyst mixture comprises the portion of the catalyst mixture fed to the second reactor system and additional second catalyst, the catalyst mixture in the first stage reactor thus having a higher concentration of second catalyst than in the catalyst regenerator, and wherein the contacting produces a first stage reactor effluent comprising a treated waste plastic pyrolysis oil having a reduced contaminant concentration, the first catalyst, and the second catalyst containing trapped contaminants;

separating the first stage reactor effluent to produce a first stream, comprising the first catalyst and the treated waste plastic pyrolysis oil having a reduced contaminant concentration, and a second stream, comprising the second catalyst;

feeding the second stream, as the additional second catalyst, to the first stage reactor, thereby concentrating the second catalyst within the first stage reactor; and

feeding the first stream to a second stage reactor to crack the treated waste plastic pyrolysis oil to recover a second stage reactor effluent comprising spent catalyst and waste-derived olefins and other waste-derived hydrocarbons;

a first separation system configured for separating the first effluent to recover (i) a mixture of spent first catalyst and spent second catalyst and (ii) a first reactor system product stream comprising the fossil-derived olefins;

a second separation system configured for separating the second stage reactor effluent to recover (i) spent catalyst and (ii) a second stage reactor system product stream comprising the waste-derived olefins and other waste-derived hydrocarbons; and

flow lines for feeding to the catalyst regenerator each of (i) the mixture of spent first catalyst and spent second catalyst and (ii) the spent catalyst.

25. The system of claim 24, further comprising:

a first fractionation system to separate the first reactor system product stream to recover two or more fossil-derived hydrocarbon fractions; and

a second fractionation system to separate the second stage reactor system product stream and to recover two or more waste-derived hydrocarbon fractions.

26. The system of claim 25, configured for maintaining the fossil-derived hydrocarbon fractions recovered from the first reactor system separate from the waste-derived hydrocarbon fractions recovered from the second reactor system.

27. The system of claim 25 or claim 26, further comprising a polymerization configured to directly or indirectly receive a monomer recovered or derived from the waste-derived hydrocarbon fractions to produce circular polymers.

28. The system of claim 25, further comprising a flow line for feeding one or more hydrocarbon fractions recovered from the waste-derived hydrocarbon fractions to a first reactor of the second reactor system.

29. The system of claim 25, further comprising a flow line for feeding one or more hydrocarbon fractions recovered from the waste-derived hydrocarbon fractions to a second reactor of the second reactor system.

30. The system of claim 25, further comprising a flow line for withdrawing a portion of the second catalyst from a first reactor of the second reactor system.

31. A system for converting waste plastic materials into circular polymers, the system comprising:

a waste plastic pyrolysis reactor for pyrolyzing a waste polymeric feedstock to produce a waste plastic pyrolysis oil having a concentration of one or more contaminants selected from the group consisting of iron, calcium, copper, potassium, magnesium, sodium, silicon, titanium, zinc and chlorine;

a catalyst regenerator for regenerating a catalyst mixture, the catalyst mixture comprising a first catalyst and a second catalyst, wherein the second catalyst is configured to trap the one or more contaminants;

a flow line for feeding a portion of the catalyst mixture to a first reactor system;

a flow line for feeding a portion of the catalyst mixture to a second reactor system;

the first reactor system, configured for:

contacting the waste plastic pyrolysis oil with a concentrated catalyst mixture in a first reactor to remove contaminants from the waste plastic pyrolysis oil and to crack a portion of the waste plastic pyrolysis oil, wherein the concentrated catalyst mixture comprises the portion of the catalyst mixture fed to the first reactor system and additional second catalyst, the catalyst mixture in the first reactor system thus having a higher concentration of second catalyst than in the catalyst regenerator, and wherein the contacting produces a first reactor effluent comprising a treated waste plastic pyrolysis oil having a reduced contaminant concentration, the first catalyst, and the second catalyst containing trapped contaminants;

separating the first reactor effluent to produce a first stream, comprising the first catalyst and the treated waste plastic pyrolysis oil having a reduced contaminant concentration, and a second stream, comprising the second catalyst;

feeding the second stream, as the additional second catalyst, to the first reactor, thereby concentrating the second catalyst within the first reactor system; and

a separation system to recover a first separation effluent comprising spent first catalyst and a second separation effluent comprising the treated waste plastic pyrolysis oil;

a fractionation system to fractionate the treated waste pyrolysis oil into three or more hydrocarbon fractions, including a light olefin fraction, a naphtha fraction, and a treated pyrolysis oil fraction;

a flow line for feeding at least one of the naphtha fraction and the treated pyrolysis oil fraction to a second reactor system,

the second reactor system, configured for contacting the at least one of the naphtha fraction and the treated pyrolysis oil fraction with the catalyst mixture to crack a portion of the hydrocarbons therein to produce a second reactor system effluent comprising waste-derived olefins, first catalyst, and second catalyst;

a separation system configured for separating the second reactor system effluent to recover (i) a mixture of spent first catalyst and spent second catalyst and (ii) a second reactor system product stream comprising the waste-derived olefins; and

flow lines for feeding to the catalyst regenerator each of (i) the mixture of spent first catalyst and spent second catalyst and (ii) the first separation effluent comprising spent first catalyst.

32. A system for producing raw materials for producing truly circular polymers, the system comprising:

a first reactor system comprising a first stage reactor and a second stage reactor, configured for:

feeding a waste polymer mixture to the first stage reactor to pyrolyze polymers therein and to recover a pyrolyzed effluent;

feeding a waste-derived plastic pyrolysis oil and a catalyst mixture to the second stage reactor to crack hydrocarbons therein and to recover an effluent comprising cracked hydrocarbons;

feeding the pyrolyzed effluent from the first stage reactor and the effluent from the second stage reactor to a first fractionation system to separate the effluents into two or more waste-derived hydrocarbon streams including the waste-derived plastic pyrolysis oil and one or more waste-derived olefin fractions;

a second reactor system configured for processing a fossil-based feedstock with the catalyst mixture;

a common catalyst regenerator configured for supplying the catalyst mixture to each of the first and second reactor systems;

a flow line for recovering an effluent comprising fossil-based hydrocarbon products from the second reactor system;

a second fractionation system for separating the effluent comprising fossil-based hydrocarbon products; and

flow lines for returning spent catalyst from each of the first and second reactor systems to the common catalyst regenerator;

wherein the spent catalyst from the second reactor system comprises both of:

an additive type cracking catalyst or a mixture of additive type cracking catalysts selected from the group consisting of Medium Pore Zeolites and pentasil family zeolites; and

a contaminant trapping additive or a mixture of contaminant trapping additives selected from the group consisting of MgO, CaO, CeO_2, $MgTiO_3$, $CaTiO_3$, $Li_2Ti_2O_7$ and $ZnTiO_3$, Ca/Mg, boron, a rare earth-based trapping additives, or a low chlorine FCC catalyst.

33. The system of claim 32, wherein the catalyst mixture comprises a first catalyst and a second catalyst, and wherein the second stage reactor is a catalyst-concentrating reactor system.