CLAIMS

1. A process for producing C2 and C3 hydrocarbons, comprising

a) subjecting a mixed hydrocarbon stream comprising a middle distillate to first hydrocracking in the presence of a first hydrocracking catalyst to produce a first hydrocracking product stream,

b) subjecting a second hydrocracking feed stream to a second hydrocracking in the presence of a second hydrocracking catalyst to produce a second hydrocracking product stream, wherein the second hydrocracking is more severe than the first hydrocracking and

c) subjecting a C4 hydrocracking feed stream to C4 hydrocracking optimized for converting C4 hydrocarbons into C3 hydrocarbons in the presence of a C4 hydrocracking catalyst to obtain a C4 hydrocracking product stream, wherein the C4 hydrocracking is more severe than the second hydrocracking,

wherein the first hydrocracking product stream, the second hydrocracking product stream and the C4 hydrocracking product stream are fed to a separation system which provides:

- the second hydrocracking feed stream separated from the first hydrocracking product stream,
- the C4 hydrocracking feed stream separated from the second hydrocracking product stream,
- a first recycle stream which is recycled back to the first hydrocracking,
- a second recycle stream which is recycled back to the second hydrocracking,
- a third recycle stream which is recycled back to the C4 hydrocracking,
- a hydrogen recycle stream of H2 or H2 and methane which is recycled back to the first hydrocracking, the second hydrocracking and/or the C4 hydrocracking and
- a C2 and C3 product stream of C3- hydrocarbons,

wherein the second hydrocracking feed stream is a stream of C12- hydrocarbons excluding C10-C12 hydrocarbons having di-ring structures,

wherein the first recycle stream is a stream of C13+ hydrocarbons and C10-C12 hydrocarbons having di-ring structures,

wherein the C4 hydrocracking feed stream is a stream of C5-, C4- or iC4- hydrocarbons, wherein the second recycle stream is a stream of C6+, C5+ or nC4+ hydrocarbons, and

wherein the third recycle stream is a stream of nC4+ or C4+ hydrocarbons.

2. The process according to claim 1, comprising:

a) subjecting a mixed hydrocarbon stream comprising a middle distillate to the first hydrocracking in the presence of the first hydrocracking catalyst to produce a first hydrocracking product stream,

a1) subjecting the first hydrocracking product stream to one or more separation steps to obtain

- the second hydrocracking feed stream of C12- hydrocarbons excluding C10-C12 hydrocarbons having di-ring structures and the first recycle stream,

a2) recycling at least part of the first recycle stream to step a),

b) subjecting a second hydrocracking feed stream to the second hydrocracking in the presence of a second hydrocracking catalyst to produce a second hydrocracking product stream, wherein the second hydrocracking is more severe than the first hydrocracking,

b1) subjecting the second hydrocracking product stream to one or more separation steps to obtain:

- the C4 hydrocracking feed stream of C5- hydrocarbons and a second recycle stream of C6+ hydrocarbons,
- the C4 hydrocracking feed stream of C4- hydrocarbons and a second recycle stream of C5+ hydrocarbons or
- the C4 hydrocracking feed stream of iC4- hydrocarbons and a second recycle stream of nC4+ hydrocarbons

b2) recycling at least part of the second recycle stream to step b),

c) subjecting the C4 hydrocracking feed stream to the C4 hydrocracking,

c1) subjecting the C4 hydrocracking product stream to one or more separation steps to obtain:

- a light C4 hydrocracking product stream of iC4- hydrocarbons and a third recycle stream of nC4+ hydrocarbons or
- a light C4 hydrocracking product stream of C3- hydrocarbons and a third recycle stream of C4+ hydrocarbons and

c2) recycling at least part of the third recycle stream to step c).

3. The process according to claim 2, wherein step a1) includes a separation between C4 and C5 hydrocarbons to obtain:

a stream of C4- hydrocarbons; and

wherein the second hydrocracking feed stream comprises C5-C12 hydrocarbons, and

wherein the stream of C4- hydrocarbons is subjected to the C4 hydrocracking of step c).

4. The process according to claim 2, wherein step a1) includes a separation between C3 and C4 hydrocarbons to obtain:
a stream of C3- hydrocarbons; and
the second hydrocracking feed stream, wherein the second hydrocracking feed stream comprises C4-C12 hydrocarbons.

5. The process according to claim 4, wherein the second hydrocracking catalyst is a catalyst containing at least selected from the group consisting of group VIII, VIB or VIIB of the periodic classification of elements, wherein the metal is deposited on a carrier.

6. The process according to claim 2, wherein step b1) includes a separation between C3 and C4 hydrocarbons to obtain: a stream of C3- hydrocarbons; and the C4 hydrocracking feed stream.

7. The process according to claim 2, wherein the process further comprises the step of subjecting a part of the second recycle stream to a third hydrocracking cracking in the presence of a third hydrocracking catalyst to produce a third hydrocracking product stream which is substantially free from non-aromatic C6+ hydrocarbons, wherein the third hydrocracking is more severe than the second hydrocracking and less severe than the C4 hydrocracking.

8. The process according to claim 2, wherein:
step a1) includes a separation of H2 or H2 and methane from the first hydrocracking product stream,
step b1) includes a separation of H2 or H2 and methane from the second hydrocracking product stream, and/or
step c1) includes a separation of H2 or H2 and methane from the C4 hydrocracking product stream.

9. The process according to claim 1, wherein the second hydrocracking is a hydrocracking process suitable for converting a hydrocarbon feed comprising naphthenic and paraffinic hydrocarbon compounds to a stream rich in LPG and aromatic hydrocarbons.

10. The process according to claim 1, wherein the C4 hydrocracking catalyst comprises a mordenite or erionite.

11. The process according to claim 1, wherein the C4 hydrocracking catalyst consists of mordenite and an optional binder or comprises sulfided-nickel/H-Erionite and the C4 hydrocracking is performed under conditions comprising a temperature between 325 and 450°C, a hydrogen partial pressure between 2 and 4 MPa, a molar ratio of hydrogen to hydrocarbon feed of 2:1 to 8:1, wherein the number of moles of the hydrocarbon feed is based on the average molecular weight of the hydrocarbon feed and a VVH of 0.5 to 5 h^{-1}.

12. The process according to claim 1, wherein the amount of methane in the first hydrocracking product stream is at most 5 wt%.

13. The process according to claim 1, wherein the amount of methane in the second hydrocracking product stream is at most 5 wt%.

14. The process according to claim 1, wherein the amount of the C2-C3 hydrocarbons in the C4 hydrocracking product stream is at least 60 wt%.

15. The process according to claim 1, wherein the second hydrocracking catalyst is a catalyst containing at least one metal selected from the group consisting of group VIII, group VIB and group VIIB of the periodic classification of elements, wherein the metal is deposited on a carrier.

16. The process according to claim 1, wherein the C4 hydrocracking catalyst consists of mordenite and a binder.

17. The process according to claim 1, wherein the C4 hydrocracking catalyst comprises sulfided-nickel/H-Erionite and the C4 hydrocracking is performed under conditions comprising a temperature between 325 and 450°C, a hydrogen partial pressure between 2 and 4 MPa, a molar ratio of hydrogen to hydrocarbon feed of 2:1 to 8:1, wherein the number of moles of the hydrocarbon feed is based on the average molecular weight of the hydrocarbon feed and a VVH of 0.5 to 5 h-1.

18. The process according to claim 2, wherein the second hydrocracking catalyst is a catalyst containing at least one metal selected from the group consisting of group VIII, group VIB and group VIIB of the periodic classification of elements, wherein the metal is deposited on a carrier.

19. The process according to claim 3, wherein the second hydrocracking catalyst is a catalyst containing at least one metal selected from the group consisting of group VIII, group VIB and group VIIB of the periodic classification of elements, wherein the metal is deposited on a carrier.

20. The process according to claim 19, wherein the amount of methane in the first hydrocracking product stream is at most 5wt%.