CLAIMS

1. A method for the production of liquid hydrocarbon composition, comprising

i) providing carbonaceous feedstock (a);

ii) subjecting the carbonaceous feedstock (a) to catalytic hydroliquefaction (10) in the presence of hydrogen to obtain a product mixture comprising liquid hydrocarbons and off-gas comprising carbon monoxide (CO), carbon dioxide (CO_2), hydrogen (H_2), water vapor (H_2O), light (C_1-C_3) hydrocarbons, and light oxygenates;

iii) separating (20) the liquid hydrocarbons and the off-gas to obtain a first liquid fraction (b-1) comprising liquid hydrocarbons and a first gaseous fraction (c-1) comprising carbon monoxide (CO), carbon dioxide (CO_2), hydrogen (H_2), water vapor (H_2O), light (C_1-C_3) hydrocarbons, and light oxygenates;

iv) converting (30) in gas phase at least part of the light oxygenates comprised in the first gaseous fraction (c-1) to deoxygenated hydrocarbons, carbon monoxide (CO), carbon dioxide (CO_2), and water vapor (H_2O), and

v) converting in the presence of water steam at least part of the carbon monoxide (CO) comprised in the first gaseous fraction (c-1) and/or produced in step iv) to carbon dioxide (CO_2) and hydrogen (H_2) by water gas shift reaction,

to obtain a CO_2 and H_2 enriched first gaseous fraction (c-1e), wherein steps iv) and v) are preferably accomplished in the same reactor step-up, more preferably in a fixed bed reactor; and

vi) separating (40) non-condensables from the CO_2 and H_2 enriched first gaseous fraction (C-1e) to obtain a second gaseous fraction (c-2) comprising CO, CO_2, H_2, and non-condensable hydrocarbons and a second liquid fraction (b-2) comprising condensable hydrocarbons;

vii) recovering (50) at least part, such as 50 to 80 %, preferably essentially all, of H_2 from the second gaseous fraction (c-2) and recirculating (93) at least part, preferably all, of the recovered H_2 to step ii);

viii) recovering the first liquid fraction (b-1) and/or the second liquid fraction (b-2) to provide a liquid hydrocarbon composition.

2. The method as claimed in claim 1, wherein step vii) is accomplished by

x) recovering H_2 from at least part of the second gaseous fraction (c-2) and recirculating at least part, preferably all, of the recovered H_2 to step ii) and partially oxygenating (POx) at least part of the H_2 depleted second gaseous fraction to convert at least part of the light hydrocarbons comprised in the H_2 depleted second gaseous fraction to syngas to further produce hydrogen and to increase CO_2:light hydrocarbon ratio of the second gaseous fraction to obtain a H_2 and CO_2 enriched second gaseous fraction (c-2e);

xi) removing CO_2 from the H_2 and CO_2 enriched second gaseous fraction (c-2e) to obtain a CO_2 depleted second gaseous fraction (c-2t) comprising H_2 and CO; and

xii) recirculating at least part, preferably all, of the CO_2 depleted second gaseous fraction (c-2t) to steps iv) and/or v).

3. The method as claimed in claim 2, wherein step vii) is accomplished by

xiii) subjecting the second gaseous fraction (c-2) to steam reforming to convert at least part of the non-condensable hydrocarbons comprised in the second gaseous fraction (c-2) to carbon dioxide (CO_2) and hydrogen (H_2); and

xiv) converting in the presence of water vapor at least part of the carbon monoxide (CO) comprised in the second gaseous fraction (c-2) and/or produced in step xiii) to carbon dioxide (CO_2) and hydrogen (H_2);

to obtain a CO_2 and H_2 enriched second gaseous fraction (c-2r) and recovering at least part, preferably all, of the H_2, and optionally CO2, comprised CO_2 and H_2 enriched second gaseous fraction (c-2r) and recirculating at least part of the recovered H_2 to step ii).

4. The method as claimed in any of claims 1 to 3, wherein step ii) is accomplished by

ii-1) subjecting the carbonaceous feedstock (a) to catalytic hydroliquefaction in the presence of hydrogen to obtain an intermediate product mixture comprising partially treated carbonaceous material, deoxygenated liquid hydrocarbons, and off-gas comprising carbon monoxide (CO), carbon dioxide (CO_2), hydrogen (H_2), water vapor (H_2O), light (C_1-C_3) hydrocarbons, and light oxygenates;

ii-2) optionally separating and removing at least part of the non-hydrogen gases comprised in the off-gas formed in step ii-1 from the intermediate product mixture to obtain a hydrogen enriched off-gas fraction (c-h) and a second off-gas fraction (c-o)

comprising carbon monoxide (CO), carbon dioxide (CO_2), light (C_1-C_3) hydrocarbons, and light oxygenates;

ii-3) subjecting the intermediate product mixture to catalytic hydroliquefaction in the presence of hydrogen and optionally the hydrogen enriched off-gas fraction (c-h) resulting from step ii-2) to obtain a product mixture comprising liquid hydrocarbons and off-gas comprising carbon monoxide (CO), carbon dioxide (CO_2), hydrogen (H_2), water vapor (H_2O), light (C_1-C_3) hydrocarbons, and light oxygenates.

5. The method as claimed in any one of claims 1 to 4, wherein recovering in step viii) comprises upgrading and distillation.

6. The method as claimed in any one of claims 1 to 5, wherein the catalytic hydroliquefaction in step ii) is carried out at a temperature from 250 to 450 °C, such as from 270 to 420 °C, preferably from 300 to 400 °C, more preferably from 320 to 390 °C.

7. The method as claimed in any of claims 1 to 6, wherein the catalytic hydroliquefaction in step ii) is carried out at a pressure of at least 6 MPa, such as from 6 to 30 MPa, preferably at least 7 MPa, such as from 7 to 16 MPa, more preferably at least 8 MPa, such as from 8 to 14 MPa, given as gauge pressure.

8. The method as claimed in any of claims 1 to 7, wherein the catalyst in the catalytic hydroliquefaction step is selected from sulfided heterogeneous metal catalysts, preferably from sulfided NiMo, sulfided CoMo, and sulfided Mo based catalysts.

9. The method as claimed in any of claims 1 to 8, wherein the carbonaceous feedstock comprises or consists of, preferably consists of, biomass feedstock, such as lignocellulosic biomass feedstock.

10. The method as claimed in any of claims 1 to 9, wherein the carbonaceous feedstock comprises at least 10 wt%, preferably at least 20 wt%, more preferably at least 30 wt%, oxygen on a dry basis, measured as elemental oxygen.

11. The method as claimed in any of claims 1 to 10, wherein the carbonaceous feedstock comprises from 45 to 55 wt%, carbon, and less than 10 wt%, such as from 5 to 8 wt%, hydrogen on a dry basis, measured as elemental carbon and hydrogen, respectively.

12. The method as claimed in any of claims 1 to 11, wherein the conversions in steps vi) and v) are carried out at a temperature from 200 to 500 °C, such as from

250 to 400 °C, preferably from 300 to 350 °C, more preferably from 310 to 320 °C and at a pressure from 0.5 to 30 MPa, such as from 0.5 to 15 MPa or 0.5 to 10 MPa, preferably from 2 to 8 MPa, more preferably from 4 to 8 MPa, given as gauge pressure.

13. The method as claimed in any of claim 1 to 12, wherein the gas hourly space velocity (GHSV) in conversion steps iv) and v) is from 1500 to 15000 h^{-1}, preferably from 2000 to 10000, more preferably from 3000 to 5000 h^{-1}.