

WHAT IS CLAIMED IS:

1. A process for improving the yield of liquid hydrocarbons from a thermal conversion process comprising:

contacting a hydrocarbon feedstock with an effective amount of sodium metal and an effective amount of exogenous capping agent at a temperature of 250-500°C, to produce a mixture of sodium salts and a converted feedstock, wherein

the hydrocarbon feedstock comprises hydrocarbons with a sulfur content of at least 0.5 wt%, an asphaltene content of at least 1 wt% and micro carbon residue content of at least 5 wt%;

the converted feedstock comprises hydrocarbons with a sulfur content less than that in the hydrocarbon feedstock, a micro carbon residue content less than that in the hydrocarbon feedstock and an asphaltene content less than that in the hydrocarbon feedstock; and

subjecting the converted feedstock to a thermal conversion process to produce a gaseous product, a purified product and a residual product, wherein

the proportion of purified product to residual product is greater than that produced by subjecting the hydrocarbon feedstock in the same thermal conversion process.

2. A process comprising:

contacting a hydrocarbon feedstock with an effective amount of sodium metal and an effective amount of exogenous capping agent at a temperature of 250-500°C, to produce a mixture of sodium salts and a converted feedstock, wherein

the hydrocarbon feedstock comprises hydrocarbons with a sulfur content of at least 0.5 wt%, an asphaltene content of at least 1 wt%, a vanadium content of at least 15 ppm and a micro carbon residue content of at least 5 wt%;

the converted feedstock comprises hydrocarbons with a sulfur content less than that in the hydrocarbon feedstock, micro carbon residue less than

that in the hydrocarbon feedstock and an asphaltene content less than that in the hydrocarbon feedstock; and

subjecting the converted feedstock to a thermal conversion process to produce a premium anode grade coke product with less than 0.5% wt% sulfur and less than 150 ppm vanadium.

3. A process comprising:

contacting a hydrocarbon feedstock with an effective amount of sodium metal and an effective amount of exogenous capping agent at a temperature of 250°C - 500°C, to produce a mixture of sodium salts and a converted feedstock, wherein

the hydrocarbon feedstock comprises hydrocarbons with a sulfur content of at least 0.5 wt%, an asphaltene content of at least 1 wt%, a nickel content of at least 10 ppm and a micro carbon residue content of at least 5 wt%;

the converted feedstock comprises hydrocarbons with a sulfur content less than 0.5 wt%, micro carbon residue less than that in the hydrocarbon feedstock and an asphaltene content less than 0.25 wt% and an ash content <0.1 wt%; and

treating the converted feedstock in a thermal conversion process to produce a high purity needle coke product with less than 0.5 wt% sulfur, less than 0.7 wt% nitrogen, less than 10 ppm nickel, a coefficient of thermal expansion greater than $2.5 \times 10^{-7}/^{\circ}\text{C}$ and an electrical resistivity of $320 \times 10^6 \text{ Ohm-In}$.

4. A process comprising:

contacting a hydrocarbon feedstock with an effective amount of sodium metal and an effective amount of exogenous capping agent at a temperature of 250°C - 500°C, to produce a mixture of sodium salts and a converted feedstock, wherein

the hydrocarbon feedstock comprises hydrocarbons with a sulfur content of at least 0.5 wt%, an asphaltene content of at least 1 wt% and a total metal content of at least 100 ppm;

the converted feedstock comprises hydrocarbons having a sulfur content less than 0.5 wt%, a vanadium content less than 50 ppm, a nickel content less than 50 ppm, a lower concentration of asphaltenes than that in the hydrocarbon feedstock, and a greater proportion of lower boiling point hydrocarbons (<538°C) to residual hydrocarbons (>538°C) than that in the hydrocarbon feedstock;

optionally further subjecting the converted feedstock to a thermal conversion process to provide a double-converted product; and

subjecting the converted feedstock or double-converted feedstock to a catalytic conversion process to produce a fuel grade product without blending or further conversion processing.

5. A process comprising:

contacting a hydrocarbon feedstock with an effective amount of sodium metal and an effective amount of exogenous capping agent at a temperature of 250°C - 500°C, to produce a mixture of sodium salts and a converted feedstock, wherein

the hydrocarbon feedstock comprises hydrocarbons with a sulfur content of at least 0.5 wt%, an asphaltene content of at least 1 wt% and fails to meet one or more fuel-grade specifications selected from the group consisting of viscosity, density, micro carbon residue, metals content and cleanliness/compatibility;

the converted product comprises a hydrocarbon having a sulfur content less than 0.5 wt%, and meets one or more fuel grade specifications selected from the group consisting of viscosity, density, micro carbon residue, metals content and compatibility; and

the fuel-grade specifications are viscosity of less than 380 cSt @ 50 C, a density of less than 991 kg/m³, a micro carbon residue content less

than 18 wt%, a vanadium content less than 350 mg/kg and a cleanliness spot test result of 1 or 2 as measured by ASTM D4740.

6. The process of claim 4 further comprising
subjecting the converted feedstock to a thermal conversion process to provide the double-converted feedstock as and a solid coke product,
wherein

the converted feedstock has a microcarbon residue content of at least 5 wt%,
and

the double-converted product comprises

a hydrocarbon having a lower concentration of impurities than that in the hydrocarbon feedstock, and

a proportion of lower boiling point hydrocarbons (<538°C) to higher boiling point residuum hydrocarbons (>538°C) greater than that of the converted feedstock.
7. The process of any one of claims 1- 6, further comprising pretreating the hydrocarbon feedstock before the contacting step to provide a purified feedstock and a pretreated hydrocarbon feedstock, wherein

the purified feedstock comprises a lower concentration of impurities than the hydrocarbon feedstock before pretreatment,

the pretreated hydrocarbon feedstock comprises a higher concentration of impurities than the purified feedstock, and

the pretreated hydrocarbon feedstock is the feedstock subjected to the contacting step to produce the converted feedstock.
8. The process of claim 7, wherein the pretreatment step comprises phase separation by an externally applied field, separation by addition of heat, hydroconversion, thermal conversion, catalytic conversion, catalytic treatment, solvent extraction, solvent deasphalting or a combination of any two or more thereof.

9. The process of claim 7 or claim 8, wherein the pretreatment step further comprises contacting the hydrocarbon feedstock with exogenous hydrogen and/or a catalyst to remove one or more of sulfur, nitrogen, oxygen, metals and asphaltenes.
10. The process of any one of claims 1-9, wherein the thermal conversion process comprises visbreaking, delayed coking, fluid coking, Flexicoking™, pyrolysis, a variant thereof or a combination of any two or more thereof.
11. The process of claim 10 wherein the thermal conversion process is operated at a temperature of about 400°C to about 570°C
12. The process of claim 10 or claim 11 wherein the thermal conversion process is operated at a pressure of about 10 to about 200 psig.
13. The process of any one of claims 1-12 wherein the thermal conversion process is operated at about 450°C to about 500°C and at about 20-100 psig.
14. The process of claim 4 wherein the catalytic conversion process comprises fluid catalytic cracking (FCC), residual FCC, hydrotreating, residual hydrotreating, hydrocracking, catalytic reforming, hydrodesulfurization, hydrodenitrogenation, hydrodemetallation, or residue upgrading/hydroconversion, their variants or a combination of any two or more thereof.
15. The process of claim 14 wherein the catalyst comprises cobalt, molybdenum, nickel, tungsten, platinum, palladium, alumina, silica, zeolites, their isomers, oxides, sulfides or combinations of any two or more thereof.
16. The process of claim 15 wherein the catalytic conversion process is operated at a temperature from about 250°C to about 575°C
17. The process of claim 15 wherein the catalytic conversion process is operated at a pressure of about 10 to about 3000 psig.
18. The process of any one of claims 4 or 6-17 wherein the catalytic conversion process is operated at about 400°C to about 575°C and at about 1000 to about 3000 psig.
19. The process of any one of claims 4 or 6-17 wherein the catalytic conversion process is operated at about 450°C to about 575°C and at about 15 to about 100 psig.

20. The process of any of any one of claims 1 to 19 further comprising recovering hydrogen sulfide using a sulfur recovery unit in conjunction with the thermal or catalytic conversion step, wherein the capacity of the sulfur recovery unit is increased proportionately to the sulfur converted to sodium salts during treatment with sodium.
21. The process of any one of claims 1-20, wherein the hydrocarbon feedstock is or is derived from a virgin crude oil or a product of a thermal cracking process.
22. The process of any one of claims 1-20, wherein the hydrocarbon feedstock is selected from the group consisting of petroleum, heavy oil, bitumen, shale oil, and oil shale.
23. The process of any one of claims 1-22, wherein the sulfur content ranges from 0.5 wt% to 15 wt%.
24. The process of any one of claims 1-23, wherein the asphaltene content ranges from 1 wt% to 100 wt%.
25. The process of claim 24, wherein the asphaltene content ranges from 2 wt% to 40 wt%.
26. The process of any one of claims 1-25 wherein the hydrocarbon feedstock comprises one or more of refinery intermediate streams, hydrocracker residue, hydroprocessing residue, FCC slurry, residual FCC slurry, atmospheric or vacuum residuums, solvent deasphalting tar, deasphalted oil, visbreaker tar, high sulfur fuel oil, low sulfur fuel oil, asphaltenes, asphalt, steam cracked tar, LC-Fining® residue, or H-Oil® residue.
27. The process of any one of claims 1 - 26, wherein the hydrocarbon feedstock has a viscosity from 1 to 10,000,000 cSt at 50°C and a density of 800 to 1200 kg/m³ at 15.6°C.
28. The process of claim 1 - 27, wherein the hydrocarbon feedstock has a viscosity from 400 to 9,000,000 cSt at 50°C.
29. The process of any one of claims 1 - 28 wherein the hydrocarbon feedstock is a solid at room temperature
30. The process of any one of claims 1 - 29, wherein the sulfur content comprise asphaltenic sulfur and non-asphaltenic sulfur, and the proportion of asphaltenic sulfur

to non-asphaltenic sulfur in the converted feedstock is lower than in the hydrocarbon feedstock.

31. The process of any one of claims 1 - 30 wherein the viscosity of the converted feedstock is reduced by at least 50 cSt at 50°C or 40% and the density of the converted feedstock is reduced by about 5 to about 25 kg/m³ per wt% of the reduction in sulfur content of the converted feedstock compared to the hydrocarbon feedstock.
32. The process of any one of claims 1 - 31 wherein the iron and vanadium content of the converted feedstock have been reduced by at least 40% compared to the hydrocarbon feedstock.
33. The process of any one of claims 1 - 32 wherein the nickel content of the converted feedstock has been reduced by at least 40% compared to the hydrocarbon feedstock.
34. The process of any one of claims 1 - 33 wherein at least 40% of the asphaltene content in the hydrocarbon feedstock is converted to a liquid hydrocarbon oil in the converted feedstock.
35. The process of any preceding claim wherein the exogenous capping agent is hydrogen, hydrogen sulfide, natural gas, methane, ethane, propane, butane, pentane, ethene, propene, butene, pentene, dienes, isomers of the foregoing, or a mixture of any two or more thereof.
36. The process of any preceding claim wherein the hydrocarbon feedstock is combined with sodium metal at a pressure of about 400 psig to about 3000 psig
37. The process of any preceding claim wherein the reaction of hydrocarbon feedstock with sodium metal occurs for a time from 1 minute to 120 minutes.
38. The process of any preceding claim further comprising separating the sodium salts from the converted feedstock.
39. The process of claim 38 wherein the separating comprises
 - a. heating the mixture of sodium salts and converted feedstock with elemental sulfur to a temperature from about 150°C to 500°C to

provide a sulfur-treated mixture comprising agglomerated sodium salts; and

- b. separating the agglomerated sodium salts from the sulfur treated mixture, to provide a desulfurized liquid hydrocarbon and separated sodium salts.

- 40. The process of claim 39 further comprising electrolyzing the separated sodium salts to provide sodium metal and elemental sulfur.
- 41. The process of any preceding claim, wherein the sodium salts comprise one or more of sodium sulfide, sodium hydrosulfide, or sodium polysulfide.
- 42. The process of claim 40 or claim 41, wherein the electrolyzing is carried out in an electrochemical cell comprising an anolyte compartment, a catholyte compartment, a NaSICON membrane that separates the anolyte compartment from the catholyte compartment, wherein a cathode comprising sodium metal is disposed in a catholyte in the catholyte compartment, an anode comprising the sodium salts are disposed in anolyte in the anolyte compartment, and an electrical power supply is electrically connected to the anode and cathode.