CLAIMS

1. A process for preparing a low sulfur liquid hydrocarbon product comprising:

i) blending a first process stream comprising a tar stream with a utility fluid to reduce the viscosity of the first process stream and obtain a second process stream comprising reduced reactivity, lower viscosity tar;

ii) removing solids from the second process stream to provide a third process stream comprising a reduced reactivity, lower viscosity tar that is substantially free of solids of size larger than 25 μm;

iii) pretreating the third process stream to further lower the reactivity of the reduced reactivity, lower viscosity tar and obtain a fourth process tar stream;

iv) mixing a pre-pyrolysis flash bottoms stream with at least one of the first process stream, the second process stream, the third process stream, and the fourth process stream to form a mixed stream comprising 10 wt. % or more of the flash bottoms stream, a weight ratio of the flash bottoms stream to the tar stream being 1.5 or less, the pre-pyrolysis flash bottoms stream having a T5 distillation point of 400°C or more;

v) hydrogenating and desulfurizing the fourth process stream and recovering a total liquid product (TLP);

vi) distilling the TLP and recovering a mid-cut of the distillation products and a heavy bottoms fraction, the mid-cut of the distillation products having a S_{BN} of 100 or more; and

vii) desulfurizing the heavy bottoms fraction to obtain a low sulfur product having a sulfur content of 1.0 wt. % or less.

2. The process of claim 1, further comprising:

separating a lower boiling fraction and a first bottoms fraction from a feedstock, the lower boiling fraction having a T95 distillation point of 455°C or less, the first bottoms fraction comprising the pre-pyrolysis flash bottoms stream; and

performing pyrolysis on at least a portion of the lower boiling fraction to form at least a pyrolysis tar product, the pyrolysis tar product comprising the tar stream.

---

3. The process of claim 1 or claim 2, wherein the pre-pyrolysis flash bottoms stream has a S_{BN} of 80 or more; or wherein the pre-pyrolysis flash bottoms stream further comprises a flash

bottoms solvent; or wherein the weight ratio of the flash bottoms stream to the tar stream is 1.5 or less; or a combination thereof.

4. The process of any of the preceding claims, further comprising recycling a portion of the mid-cut as at least a portion of the utility fluid used in step i), the mid-cut optionally having a S_{BN} of 80 or more.

5. The process of any of the preceding claims, further comprising heat soaking the tar stream prior to blending the first process stream with the utility fluid, wherein the heat soaking step is performed at a temperature in the range of from 200°C to 300°C, and for a time in the range of from 2 minutes to 30 minutes.

6. The process of any of the preceding claims, wherein the hydrogenating and desulfurizing step v) adds from 1000 SCF/B to 2000 SCF/B of molecular hydrogen on a feed basis to the fourth process stream and reduces sulfur content of the fourth process stream by 80 wt. % to 95 wt. %; or wherein the hydrogenating and desulfurizing step v) is performed at a temperature in the range of from 340°C to 410°C and a space velocity (WHSV, feed basis) in the range of from 0.5 hr^{-1} to 1.5 hr^{-1}; or a combination thereof.

7. The process of any of the preceding claims, wherein the heavy bottoms desulfurizing step vii) provides a product having a sulfur content of 0.2 wt. % or less.

8. The process of any of the preceding claims, further comprising passing the product of step ii) through a guard reactor that further removes reactive olefins and residual solids before step iii), the guard reactor being operated at a temperature in the range of from 240°C to 320°C and a space velocity (WHSV, feed basis) in the range of from 2 hr^{-1} to 10 hr^{-1}.

9. The process of claim 8, wherein the flash bottoms stream is mixed with at least one of the first process stream, the second process stream, and the third process stream.

~~10. The process of claim 8 or claim 9, wherein at least one of the catalysts of step v) contains one or more of Co, Ni, or Mo; or wherein at least one of the catalysts in the guard reactor contains one or more of Co, Ni, or Mo; or wherein the desulfurizing step viii) is performed in a reactor packed with a catalyst that contains one or more of Co, Ni, or Mo; or a combination thereof.~~

~~11. The process of any of the preceding claims, wherein the pretreating step (iii) is performed at a temperature in the range of from 260°C to 300°C and a feed weight hourly space velocity (WHSV) in the range of from of 1.0 hr^{-1} to 4.0 hr^{-1}.~~

~~12. The process of any of the preceding claims, further comprising blending the low sulfur product with one or more additional fractions to produce an ECA stream that includes the low sulfur product, a low sulfur fuel oil stream that includes the low sulfur product, or a combination thereof.~~

~~13.~~1. A process for preparing a low sulfur liquid hydrocarbon product comprising:

i) blending a first process stream comprising a tar stream with a utility fluid to reduce the viscosity of the first process stream and obtain a second process stream comprising reduced reactivity, lower viscosity tar;

ii) removing solids from the second process stream to provide a third process stream comprising a reduced reactivity, lower viscosity tar that is ~~substantially~~ free of solids of size larger than 25 μm;

iii) pretreating the third process stream to further lower the reactivity of the tar and obtain a fourth process tar stream;

iv) hydrogenating and desulfurizing the fourth process stream and recovering a total liquid product (TLP);

v) distilling the TLP and recovering a mid-cut of the distillation products and a heavy bottoms fraction;

vi) mixing at least a portion of the heavy bottoms fraction with a pre-pyrolysis flash bottoms stream to form a mixed feed comprising 25 wt. % or more of the heavy bottoms fraction and having a weight ratio of heavy bottoms fraction to pre-pyrolysis flash bottoms stream of 0.5 or more, the pre-pyrolysis flash bottoms stream having a T5 distillation point of 400°C or more; and

vii) desulfurizing the mixed feed to obtain a low sulfur product having a sulfur content of ~~about~~ 1.0 wt. % or less.

~~14.~~2. The process of claim ~~13~~ 1, further comprising:

separating a lower boiling fraction and a first bottoms fraction from a feedstock, the lower boiling fraction having a T95 distillation point of 455°C or less, the first bottoms fraction comprising the pre-pyrolysis flash bottoms stream; and

performing pyrolysis on at least a portion of the lower boiling fraction to form at least a pyrolysis tar product, the pyrolysis tar product comprising the tar stream.

~~15.~~3. The process of claim ~~13~~ 1 or claim ~~14~~ 2, wherein the pre-pyrolysis flash bottoms stream has a S_{BN} of 80 or more; or wherein the pre-pyrolysis flash bottoms stream further comprises a flash bottoms solvent; or a combination thereof.

~~16.~~4. The process of any of claims ~~13 to 15~~ 1 to 3, further comprising blending the low sulfur product with one or more additional fractions to produce an emission control area (ECA) stream that includes the low sulfur product, a low sulfur fuel oil stream that includes the low sulfur product, or a combination thereof.

~~17.~~5. The process of any of claims ~~13 to 16~~ 1 to 4, further comprising heat soaking the tar stream prior to blending the first process stream with the utility fluid, wherein the heat soaking step is performed at a temperature in the range of from 200°C to 300°C, and for a time in the range of from 2 minutes to 30 minutes.

~~18.~~6. The process of any of claims ~~13 to 17~~ 1 to 5, wherein the solids removal step ii) includes centrifugation.

~~19.~~7. The process of any of claims ~~13 to 18~~ 1 to 6, further comprising passing the ~~product~~ third process stream of ~~the~~ step ii) through a guard reactor that further removes reactive olefins and residual solids before step iii), the guard reactor being operated at a temperature in the range of

from 240°C to 320°C and a space velocity (WHSV, feed basis) in the range of from 2.0 hr^{-1} to 10 hr^{-1}.

~~20.~~8. The process of any of claims ~~13 to 19~~ 1 to 7, further comprising recycling a portion of the mid-cut as at least a portion of the utility fluid used in step i), and wherein 70 wt. % to 85 wt. % of the recycled mid-cut is included in the utility fluid.

~~21.~~9. The process of any of claims ~~13 to 20~~ 1 to 8, wherein the pretreatment step (iii) is performed at a temperature in the range of from 260°C to 300°C and a feed weight hourly space velocity (WHSV) in the range of from of 1.0 hr^{-1} to 4.0 hr^{-1}.

~~22.~~10. The process of any of claims ~~13 to 21~~ 1 to 9, wherein the hydrogenating and desulfurizing step ~~v)~~ iv) adds from 1000 SCF/B (178 m^3/m^3) to 2000 SCF/B (356 m^3/m^3) of molecular hydrogen on a feed basis to the fourth process stream and reduces sulfur content of the fourth process stream by 50 wt. % to 95 wt. %; or wherein the hydrogenating and desulfurizing step ~~v)~~ iv) is performed at a temperature in the range of from 340°C to 410°C and a space velocity (WHSV, feed basis) in the range of from 0.5 hr^{-1} to 1.5 hr^{-1}; or a combination thereof.

~~23.~~11. The process of any of claims ~~13 to 22~~ 1 to 10, wherein the desulfurizing step vii) is performed at a temperature in the range of from 340°C to 425°C and a space velocity (WHSV, feed basis) in the range of from 0.4 hr^{-1} to 1.0 hr^{-1}.

~~24.~~12. The process of claim ~~23~~ 11, wherein ~~at least one of the catalysts of~~ the hydrogenating and desulfurizing step ~~v)~~ iv) is carried out in the presence of at least one catalyst, the at least one catalyst contains one or more of Co, Ni, or Mo; or wherein the desulfurizing step ~~viii)~~ vii) is performed in a reactor packed with a catalyst that contains one or more of Co, Ni, or Mo; or a combination thereof.

~~25.~~13. The process of any of claims ~~13 to 24~~ 1 to 12, further comprising demetallization of the pre-pyrolysis flash bottoms prior to mixing the pre-pyrolysis flash bottoms with the at least a portion of the heavy bottoms fraction.

~~26.~~14. A system for producing a low sulfur liquid product, comprising:

a flash separator having a feed inlet, a lower boiling stream outlet, and a flash bottoms outlet;

a steam cracker comprising a steam cracker inlet and a steam cracker outlet, the steam cracker inlet being in fluid communication with the lower boiling stream outlet;

a first fractionation stage comprising a first fractionation inlet, one or more first product outlets, and a tar outlet, the first fractionation inlet being in fluid communication with the steam cracker outlet;

at least one of a heat soaking vessel and a heat soaking conduit;

a particle separator comprising a particle separator inlet and a particle separator outlet, the particle separator inlet being in fluid communication with the tar outlet via the at least one heat soaking vessel and heat soaking conduit;

one or more first hydroprocessing reactors comprising a first hydroprocessor inlet and a first hydroprocessor outlet, the first hydroprocessor inlet being in fluid communication with the particle separator outlet;

a second fractionation stage comprising a second fractionation inlet, one or more light products outlets, ~~the~~ a mid-cut outlet, and a hydroprocessed bottoms outlet, the second fractionation inlet being in fluid communication with the hydroprocessor outlet; and

one or more second hydroprocessing reactors comprising a second hydroprocessor inlet and a second hydroprocessor outlet, the second hydroprocessor inlet being in fluid communication with the hydroprocessed bottoms outlet,

wherein at least one of the particle separator inlet and the first hydroprocessor inlet is further in fluid communication with the flash bottoms outlet, and

wherein at least one of the particle separator inlet and the first hydroprocessor inlet is further in fluid communication with the mid-cut outlet.

~~27.~~15. A system for producing a low sulfur liquid product, comprising:

a flash separator having a feed inlet, a lower boiling stream outlet, and a flash bottoms outlet;

a steam cracker comprising a steam cracker inlet and a steam cracker outlet, the steam cracker inlet being in fluid communication with the lower boiling stream outlet;

a first fractionation stage comprising a first fractionation inlet, one or more first product outlets, and a tar outlet, the first fractionation inlet being in fluid communication with the steam cracker outlet;

at least one of a heat soaking vessel and a heat soaking conduit;

a particle separator comprising a particle separator inlet and a particle separator outlet, the particle separator inlet being in fluid communication with the tar outlet via the at least one heat soaking vessel and heat soaking conduit;

one or more first hydroprocessing reactors comprising a first hydroprocessor inlet and a first hydroprocessor outlet, the first hydroprocessor inlet being in fluid communication with the particle separator outlet;

a second fractionation stage comprising a second fractionation inlet, one or more light products outlets, ~~the~~ a mid-cut outlet, and a hydroprocessed bottoms outlet, the second fractionation inlet being in fluid communication with the hydroprocessor outlet; and

one or more second hydroprocessing reactors comprising a second hydroprocessor inlet and a second hydroprocessor outlet, the second hydroprocessor inlet being in fluid communication with the hydroprocessed bottoms outlet and being in fluid communication with the flash bottoms outlet,

wherein at least one of the particle separator inlet and the first hydroprocessor inlet is further in fluid communication with the mid-cut outlet.

~~28.~~16. The system of claim ~~27~~ 15, further comprising a demetallization reactor, the fluid communication between the second hydroprocessor inlet and the flash bottoms outlet comprising indirect fluid communication via the demetallization reactor.

~~29. A low sulfur liquid product obtained by the process of any of claims 1 – 25 or produced by the system of any of claims 26 – 28.~~