

states, it is necessary to separate these products from the hydrocarbon materials. In many cases, a gravimetric separation, such as centrifugation or filtering, can separate the organic, upgraded oil, from the salt phase, metallic phase, and organic solids which may be formed.

[0019] Once the alkali metal compounds are separated from the hydrocarbon feedstock, sulfur and metals are substantially removed, and nitrogen is moderately removed. Also, both viscosity and density are reduced (API gravity is increased). Bitumen or heavy oil would be considered synthetic crude oil (SCO) and can be shipped via pipeline for further refining. Similarly, shale oil will have been considerably upgraded after such processing. Subsequent refining will be easier since the troublesome metals have been removed.

[0020] However, for some hydrocarbon feedstocks, gravimetric separation it is not possible without further processing. For example, the inventors have observed that certain hydrocarbon feedstocks that contain a heavy fraction of hydrocarbons, upon processing with an alkali metal produce a mixture of alkali metal compounds and reduced heavy metals that could not be separated from the upgraded hydrocarbon materials through conventional gravimetric separation.

[0021] It is an object of the present invention to provide a process to facilitate separation of alkali metal compounds, such as alkali metal sulfides and nitrides, and reduced heavy metals from alkali metal reacted hydrocarbons.

BRIEF SUMMARY

[0022] The present disclosure provides a process to facilitate separation of alkali metal compounds and reduced heavy metals from alkali metal reacted hydrocarbons.

[0022a] One aspect of the present invention relates to a process to facilitate separation of alkali metal salts from alkali metal reacted hydrocarbons comprising: reacting molten alkali metal, hydrogen and a quantity of a hydrocarbon feedstock having at least one heavy fraction to provide a mixture comprising alkali metal salts and alkali metal reacted hydrocarbons; heating a mixture resulting from a reaction of an alkali metal and a quantity of a hydrocarbon feedstock having at least one heavy fraction, said mixture comprising alkali metal salts and alkali metal reacted hydrocarbons, wherein the mixture is heated to a temperature in the range from about 350°C to 400°C; and mechanically mixing the mixture during the heating step and further comprising the step of separating gravimetrically the alkali metal salts from the
alkali metal reacted hydrocarbons.

[0022b] Another aspect relates to a process to facilitate separation of sodium sulfide from sodium-reacted hydrocarbons comprising: reacting molten sodium, hydrogen gas or dissolved liquid hydrogen and a quantity of a hydrocarbon feedstock having at least one heavy fraction to provide a mixture comprising sodium sulfide and sodium-reacted hydrocarbons; heating a mixture resulting from a reaction of molten sodium and a quantity of a hydrocarbon feedstock having at least one heavy fraction, said mixture comprising sodium sulfide and sodium-reacted hydrocarbons, wherein the mixture is heated to a temperature in the range from about 350°C to 400°C; mechanically mixing the mixture during the heating step; and separating gravimetrically the sodium sulfide from the sodium-reacted hydrocarbons.

[0022c] Yet another aspect relates to a process of upgrading a hydrocarbon feedstock comprising: obtaining a quantity of an oil~~hydrocarbon~~ feedstock having at least one heavy fraction, the hydrocarbon feedstock comprising at least one carbon atom and a sulfur heteroatom and/or one or more heavy metals; reacting the quantity of the hydrocarbon feedstock with an a molten alkali metal and an upgradant hydrocarbon~~hydrogen gas to produce an upgraded hydrocarbon feedstock, wherein the upgradant hydrocarbon comprises at least one carbon atom and at least one hydrogen atom, wherein the alkali metal reacts with the sulfur heteroatom and/or the one or more heavy metals to form one or more inorganic products comprising alkali metal sulfide or alkali metal polysulfides, and wherein the upgradant hydrocarbon reacts with the hydrocarbon feedstock to produce an upgraded hydrocarbon feedstock, wherein the number of carbon atoms in the upgraded hydrocarbon feedstock is greater than the number of carbon atoms in the hydrocarbon feedstock; heating the mixture of inorganic products and the upgradant hydrocarbon feedstock to a temperature in the range from about 350°C to 400°C; mechanically mixing the mixture during the heating step; and gravimetrically separating the inorganic products from the upgraded hydrocarbon feedstock.~~

[0022d] ~~Another aspect relates a process to facilitate separation of alkali metal salts from alkali metal reacted hydrocarbons comprising: adding a portion of the separated alkali metal salts to the mixture of alkali metal hydrocarbon feedstock having at least one heavy fraction, said mixture comprising alkali metal salts and alkali metal reacted hydrocarbons.~~

[0022e] ~~Another aspect relates a process to facilitate removal of residual alkali metal from alkali metal reacted hydrocarbons comprising mixing a flux with the hydrocarbon to dissolve the~~

~~alkali~~

~~metal.~~

[0023] Reference throughout this specification to features, advantages, or similar language does not imply that all of the features and advantages that may be realized with the present invention should be or are in any single embodiment of the invention. Rather, language referring to the features and advantages is understood to mean that a specific feature, advantage, or characteristic described in connection with an embodiment is included in at least one embodiment of the present invention. Thus, discussion of the features and advantages, and similar language, throughout this specification may, but do not necessarily, refer to the same embodiment, but may refer to every embodiment.

[0024] Furthermore, the described features, advantages, and characteristics of the invention may be combined in any suitable manner in one or more embodiments. One skilled in the relevant art will recognize that the invention may be practiced without one or more of the specific features or advantages of a particular embodiment. In other instances, additional

CLAIMS:

1. A process to facilitate separation of alkali metal salts from alkali metal reacted hydrocarbons comprising:

heating a mixture resulting from a reaction of an alkali metal and a quantity of a hydrocarbon feedstock having at least one heavy fraction, said mixture comprising alkali metal salts and alkali metal reacted hydrocarbons, wherein the mixture is heated to a temperature in the range from about 350°C to 400°C; and

mechanically mixing the mixture during the heating step.

2. The process according to claim 1, wherein the mixture is heated to a temperature of about 375°C ± 10°C.

3. The process according to claim 1, wherein the mixture is heated and mechanically mixed for a time period of over 15 minutes.

4. The process according to claim 1, wherein the mixture is heated and mechanically mixed for a time period of over 30 minutes.

5. The process according to claim 1, wherein the mixture is heated and mechanically mixed for a time period of at least 1 hour.

6. The process according to claim 1, wherein the mixture is heated and mechanically mixed for a time period between about 1 and 2 hours.

7. The process according to claim 1, wherein the quantity of a hydrocarbon feedstock comprises bitumen.

8. The process according to claim 1, further comprising the step of separating gravimetrically the alkali metal salts from the alkali metal reacted hydrocarbons.

9. The process according to claim 8, further comprising the step of adding a portion of the separated alkali metal salts to the mixture of alkali metal salts and alkali metal reacted hydrocarbons prior to heating.

10. The process according to claim 8, further comprising the step of adding a portion of the separated alkali metal salts to the hydrocarbon feedstock prior to reacting with the alkali metal.

11. A process to facilitate separation of sodium sulfide from sodium-reacted hydrocarbons comprising:

heating a mixture resulting from a reaction of molten sodium and a quantity of a hydrocarbon feedstock having at least one heavy fraction, said mixture comprising sodium

sulfide and sodium-reacted hydrocarbons, wherein the mixture is heated to a temperature in the range from about 350°C to 400°C;

mechanically mixing the mixture during the heating step; and

separating gravimetrically the sodium sulfide from the sodium-reacted hydrocarbons.

12. The process according to claim 11, wherein the mixture is heated to a temperature of about 375°C ± 10°C.

13. The process according to claim 11, wherein the mixture is heated and mechanically mixed for a time period of over 15 minutes.

14. The process according to claim 11, wherein the mixture is heated and mechanically mixed for a time period of over 30 minutes.

15. The process according to claim 11, wherein the mixture is heated and mechanically mixed for a time period of at least 1 hour.

16. The process according to claim 11, wherein the mixture is heated and mechanically mixed for a time period between about 1 and 2 hours.

17. The process according to claim 11, wherein the quantity of a hydrocarbon feedstock comprises bitumen.

18. The process according to claim 11, further comprising the step of adding a portion of the separated alkali metal salts to the mixture of alkali metal salts and alkali metal reacted hydrocarbons prior to heating.

19. The process according to claim 11, further comprising the step of adding a portion of the separated alkali metal salts to the hydrocarbon feedstock prior to reacting with the alkali metal.

20. A process of upgrading a hydrocarbon feedstock comprising:
obtaining a quantity of an oil feedstock having at least one heavy fraction, the hydrocarbon feedstock comprising at least one carbon atom and a sulfur heteroatom and/or one or more heavy metals;

reacting the quantity of the hydrocarbon feedstock with an alkali metal and an upgradant hydrocarbon, wherein the upgradant hydrocarbon comprises at least one carbon atom and at least one hydrogen atom, wherein the alkali metal reacts with the sulfur heteroatom and/or the one or more heavy metals to form one or more inorganic products comprising alkali metal sulfide or alkali metal polysulfides, wherein the upgradant hydrocarbon reacts with the hydrocarbon feedstock to produce an upgraded hydrocarbon feedstock, wherein the number of carbon atoms in the upgraded hydrocarbon feedstock is greater than the number of carbon atoms in the hydrocarbon feedstock;

heating the mixture of inorganic products the upgradant hydrocarbon to a temperature in the range from about 350°C to 400°C;

mechanically mixing the mixture during the heating step; and

separating the inorganic products from the upgraded hydrocarbon feedstock.

21. The process according to claim 20, wherein the quantity of hydrocarbon feedstock comprises bitumen.

22. The process according to claim 20, further comprising the step of adding a portion of the separated inorganic products to the mixture of inorganic products the upgradant hydrocarbon prior to heating.

23. The process according to claim 20, further comprising the step of adding a portion of the separated inorganic products to the hydrocarbon feedstock prior to reacting with the alkali metal.

24. A process to facilitate separation of alkali metal salts from alkali metal reacted hydrocarbons comprising:

adding a portion of the separated alkali metal salts to the mixture of alkali metal hydrocarbon feedstock having at least one heavy fraction, said mixture comprising alkali metal salts and alkali metal reacted hydrocarbons.

25. The process according to claim 24, further comprising adding a portion of the separated alkali metals salts to the mixture of alkali metal hydrocarbon feedstock prior to addition of the alkali metal.

26. A process to facilitate removal of residual alkali metal from alkali metal reacted hydrocarbons comprising mixing a flux with the hydrocarbon to dissolve the alkali metal.

27. The process according to claim 26, where the flux is ammonia.

28. The process according to claim 27, where the ammonia with dissolved alkali metal is flashed off to yield the alkali metal.

CLAIMS:

1. A process to facilitate separation of alkali metal salts from alkali metal reacted hydrocarbons comprising:

reacting molten alkali metal, hydrogen and a quantity of a hydrocarbon feedstock having at least one heavy fraction to provide a mixture comprising alkali metal salts and alkali metal reacted hydrocarbons;

heating said mixture comprising alkali to a temperature in the range from about 350°C to 400°C;

mechanically mixing the mixture during the heating step; and further comprising the step of separating gravimetrically the alkali metal salts from the alkali metal reacted hydrocarbons.

2. The process according to claim 1, wherein the mixture is heated to a temperature of about $375^{\circ}\text{C} \pm 10^{\circ}\text{C}$.

3. The process according to claim 1, wherein the mixture is heated and mechanically mixed for a time period of over 15 minutes.

4. The process according to claim 1, wherein the mixture is heated and mechanically mixed for a time period of over 30 minutes.

5. The process according to claim 1, wherein the mixture is heated and mechanically mixed for a time period of at least 1 hour.

6. The process according to claim 1, wherein the mixture is heated and mechanically mixed for a time period between about 1 and 2 hours.

7. The process according to claim 1, wherein the quantity of a hydrocarbon feedstock comprises bitumen, heavy oil, or a refinery stream containing a heavy fraction.

8. The process according to claim 1, further comprising the step of adding a portion of the separated alkali metal salts to the mixture of alkali metal salts and alkali metal reacted hydrocarbons prior to heating.

9. The process according to claim 1, further comprising the step of adding a portion of the separated alkali metal salts to the hydrocarbon feedstock prior to reacting with the alkali metal.

10. A process to facilitate separation of sodium sulfide from sodium-reacted hydrocarbons comprising:

reacting molten sodium, hydrogen gas or dissolved liquid hydrogen and a quantity of a hydrocarbon feedstock having at least one heavy fraction to provide a mixture comprising sodium sulfide and sodium-reacted hydrocarbons;

heating said mixture to a temperature in the range from about 350°C to 400°C;
mechanically mixing the mixture during the heating step; and
separating gravimetrically the sodium sulfide from the sodium-reacted hydrocarbons.

11. The process according to claim 10, wherein the mixture is heated to a temperature of about 375°C ± 10°C.

12. The process according to claim 10, wherein the mixture is heated and mechanically mixed for a time period of over 15 minutes.

13. The process according to claim 10, wherein the mixture is heated and mechanically mixed for a time period of over 30 minutes.

14. The process according to claim 10, wherein the mixture is heated and mechanically mixed for a time period of at least 1 hour.

15. The process according to claim 10, wherein the mixture is heated and mechanically mixed for a time period between about 1 and 2 hours.

16. The process according to claim 10, wherein the quantity of a hydrocarbon feedstock comprises bitumen, heavy oil, or a refinery stream containing a heavy fraction.

17. The process according to claim 10, further comprising the step of adding a portion of the separated sodium sulfide salts to the mixture of sodium salts and sodium-reacted hydrocarbons prior to heating.

18. The process according to claim 10, further comprising the step of adding a portion of the separated sodium sulfide salts to the hydrocarbon feedstock prior to reacting with the sodium.

19. A process of upgrading a hydrocarbon feedstock comprising:
obtaining a quantity of hydrocarbon feedstock having at least one heavy fraction, the hydrocarbon feedstock comprising at least one carbon atom and a sulfur heteroatom and/or one or more heavy metals;

reacting the quantity of the hydrocarbon feedstock with a molten alkali metal and an hydrogen gas to produce an upgraded hydrocarbon feedstock, wherein the alkali metal reacts with the sulfur heteroatom and/or the one or more heavy metals to form one or more inorganic products comprising alkali metal sulfide or alkali metal polysulfides, and

heating the mixture of inorganic products the upgraded hydrocarbon feedstock to a temperature in the range from about 350°C to 400°C;

mechanically mixing the mixture during the heating step; and

gravimetrically separating the inorganic products from the upgraded hydrocarbon feedstock.

20. The process according to claim 19, wherein the quantity of hydrocarbon feedstock comprises bitumen, heavy oil, or a refinery stream containing a heavy fraction.

21. The process according to claim 19, further comprising the step of adding a portion of the separated inorganic products to the mixture of inorganic products and the upgraded hydrocarbon prior to heating.

22. The process according to claim 19, further comprising the step of adding a portion of the separated inorganic products to the hydrocarbon feedstock prior to reacting with the alkali metal.