

CLAIMS:

Claim 1. A process for producing one or more ~~of~~-hydrocarbon products from a renewable feedstock comprising triglycerides, free fatty acids or combinations thereof, the process comprising the steps of:

diluting the renewable feedstock with a diluent to form a diluted feedstock;

contacting the diluted feedstock with hydrogen gas and sulfiding agent so that the hydrogen gas dissolves in the diluted feedstock to form a diluted feedstock enriched with dissolved hydrogen;

subjecting the diluted feedstock enriched with dissolved hydrogen to a reactor comprising a catalyst bed to form a reaction effluent ~~enriched with dissolved hydrogen~~;

further contacting the reaction effluent with hydrogen gas and sulfiding agent so that the hydrogen gas dissolves in the reaction effluent to form a reaction effluent enriched with dissolved hydrogen;

further subjecting the reaction effluent enriched with dissolved hydrogen to at least an additional reactor comprising a catalyst bed, thereby producing a further-reaction effluent which can be further processed to form one or more ~~of~~-hydrocarbon products; and

wherein gas volume fraction of undissolved hydrogen in the reactor is no more than 0.1 to 0.25.

Claim 2. The process according to claim 1 further comprising the step of passing sulfiding agent and/or hydrogen gas through each reactor at a predefined amount.

Claim 3. The process according to claim 1 further comprising the step of separating gaseous by-products from the reaction effluent or further-reaction effluent using a Hot High-Pressure Separator.

Claim 4. The process according to claim 1 further comprising the steps of

feeding the reaction effluent or further-reaction effluent to separators, which are arranged sequentially, for separating by-products from the reaction effluent or further-reaction effluent and for recovering the diluent from the reaction effluent or further-reaction effluent, thereby obtaining a hydrotreated product;

reinjecting the recovered diluent to the diluent source; and

feeding the hydrotreated product to one or more distillation columns and adsorption units for purifying the hydrotreated product to obtain one or more of purified hydrocarbon products.

Claim 5. The process according to any of the preceding claims, wherein the renewable feedstock is an animal oil, a plant oil, or a combination of one or more animal oils and one or more plant oils.

Claim 6. The process according to any of the preceding claims, wherein the renewable feedstock is tallow oil, train oil, fish oil, bleached palm oil (BPO), refined bleached deodorized palm oil (RBDPO), palm olein, palm stearin, palm fatty acid distillate, canola oil, corn oil, sunflower oil, soybean oil, jatropha oil, balanites oil, rapeseed oil, tall oil, hempseed oil, olive oil, linseed oil, mustard oil, peanut oil, castor oil, coconut oil, or a combination of any two or more oils.

Claim 7. The process according to any of the preceding claims, wherein the renewable feedstock is fresh oil, used oil, waste oil or any combination thereof.

Claim 8. The process according to any of the preceding claims, wherein the diluent comprises n-paraffin, or wherein the diluent comprises n-paraffin comprising 12 carbon atoms.

Claim 9. The process according to claim 1, wherein the ratio of the diluent to the renewable feedstock is ~~about~~ 99 wt% diluent/1 wt% feedstock to ~~about~~ 95 wt% diluent/5 wt% feedstock, ~~about~~ 95 wt% diluent/5 wt% feedstock to ~~about~~ 90 wt% diluent/10 wt% feedstock, ~~about~~ 80 wt% diluent/20 wt% feedstock to ~~about~~ 70 wt% diluent/30 wt% feedstock or ~~about~~ 60 wt% diluent/40 wt% feedstock to ~~about~~ 50 wt% diluent/50 wt% feedstock.

Claim 10. The process according to any of the preceding claims, wherein the ratio of hydrogen gas to the volume of catalyst bed in the reactor is in the range of 3, 20, 40, 50, 100, 150, 200, 250, 300, 350, 400, 500, 600, 700, 800 or 900 Nm³/m³, and/or the ratio of hydrogen gas to the renewable feedstock is in the range of ~~about~~ 10 to ~~about~~ 450 Nm³/m³/hr (~~about~~ 0.001 to ~~about~~ 0.035 g/g/hr), ~~about~~ 10 to ~~about~~ 400 Nm³/m³/hr (~~about~~ 0.001 to ~~about~~ 0.032 g/g/hr), ~~about~~ 10 to ~~about~~ 380 Nm³/m³/hr (~~about~~ 0.001 to ~~about~~ 0.030 g/g/hr), ~~about~~ 10 to ~~about~~ 350 Nm³/m³/hr (~~about~~ 0.001 to ~~about~~ 0.028 g/g/hr) or ~~about~~ 10 to ~~about~~ 320 Nm³/m³/hr (~~about~~ 0.001 to ~~about~~ 0.025 g/g/hr).

Claim 11. The process according to claim 1, wherein the catalyst comprises at least one of two transition metals selected from the group consisting of Ni and Mo.

Claim 12. The process according to claim 11, wherein the catalyst further comprises another transition metal or a group V element, and/or the catalyst is loaded on a support.

Claim 13. The process according to claim 12, wherein the support is an acidic porous solid support selected from the group comprising alumina (Al_2O_3), silica (SiO_2) and a mixture of alumina and silica ($\text{Al}_2\text{O}_3\text{-SiO}_2$).

Claim 14. The process according to claim 13, wherein the support is fluoride alumina, ZSM-12, ZSM-21, ZSM-22, ZSM-23, ZSM-32, ZSM-35, ZSM-38, ZSM-48, ZSM-57, SAPO-11, SAPO-31, SAPO-41, MAPO-11, MAPO-31, zeolite Y, zeolite L or β -zeolite.

Claim 15. The process according to claim 1, further comprising subjecting the further reaction effluent to additional processing to form bio-naptha, industrial solvents, and/or at least one phase change material as the one or more hydrocarbon products.

Claim 16. The process according to claim 15, wherein the additional processing comprises one or more separation processes to remove impurities or gaseous contaminants, followed by a plurality of distillation and adsorption processes.

Claim 17. The process of claim 16, further comprising obtaining the at least one phase change material by way of the plurality of distillation and adsorption processes, wherein the at least one phase change material comprises at least one of: at least 99.0 wt% n-hexadecane, at least 99.0 wt% n-heptadecane, and at least 99.0 wt% of n-octadecane.~~A system for producing one or more of hydrocarbon products from a renewable feedstock comprising triglycerides, free fatty acids or combinations thereof, the system comprising a reactor comprising a catalyst bed;~~

~~wherein the reactor is for reacting a diluted feedstock enriched with dissolved hydrogen to produce a reaction effluent which can be further processed to form one or more of hydrocarbon products;~~

~~wherein the diluted feedstock enriched with dissolved hydrogen is prepared by diluting a renewable feedstock comprising triglycerides, free fatty acids or~~

~~combinations thereof using a diluent to form a diluted feedstock, followed by adding a sulfiding agent and passing hydrogen gas through the diluted feedstock so that the hydrogen gas dissolves in the diluted feedstock to form a diluted feedstock enriched with dissolved hydrogen; the system according to claim 16 further comprising at least an additional reactor comprising a catalyst bed to further contacting the reaction effluent with hydrogen gas and sulfiding agent to form a reaction effluent enriched with dissolved hydrogen, the additional reactor is for reacting the reaction effluent enriched with dissolved hydrogen to produce a further reaction effluent which can be further processed to form one or more of hydrocarbon products; and~~

~~wherein the gas volume fraction of undissolved hydrogen in the reactor is no more than 0.1 to 0.25.~~

~~16. — The system according to claim 15, wherein the reactor or the additional reactor is further used so that the sulfiding agent and/or the hydrogen gas is passing through the~~

reactor at a predefined amount.

~~17. — The system according to claim 15, further comprising a Hot High Pressure Separator located after each reactor or additional reactor for separating gaseous by products from the reaction effluent or further reaction effluent.~~

~~18. — The system according to any of claim 15 to claim 17 further comprising one or more separators, which are arranged sequentially, for separating by products from the reaction effluent or further reaction effluent and for recovering the diluent from the reaction effluent or further reaction effluent, thereby obtaining a hydrotreated product; and~~

~~one or more distillation columns and adsorption units for purifying the hydrotreated product to obtain one or more of purified hydrocarbon products.~~

~~19. — The system according to any of claim 15 to claim 18, wherein the renewable feedstock is an animal oil, a plant oil, or a combination of one or more animal oils and one or more plant oils.~~

~~20. — The system according to any of claim 15 to claim 18, wherein the renewable feedstock is tallow oil, train oil, fish oil, bleached palm oil (BPO), refined bleached deodorized palm oil (RBDPO), palm olein, palm stearin, palm fatty acid distillate, canola oil, corn oil, sunflower oil, soybean oil, jatropha oil, balanites oil, rapeseed oil, tall oil, hempseed oil, olive oil, linseed oil, mustard oil, peanut oil, castor oil, coconut oil, or a combination of any two or more oils.~~

~~21. — The system according to any of claim 15 to claim 18, wherein the renewable feedstock is fresh oil, used oil, waste oil or any combination thereof.~~

~~22. — The system according to any of claim 15 to claim 18, wherein the diluent comprises n-paraffin, or wherein the diluent comprises n-paraffin comprising 12 carbon atoms.~~

~~23. — The system according to claim 15, wherein the ratio of the diluent to the renewable feedstock is about 99 wt% diluent/1 wt% feedstock to about 95 wt% diluent/5 wt% feedstock, about 95 wt% diluent/5 wt% feedstock to about 90 wt% diluent/10 wt% feedstock, about 80 wt% diluent/20 wt% feedstock to about 70 wt% diluent/30 wt% feedstock or about 60 wt% diluent/40 wt% feedstock to about 50 wt% diluent/50 wt%~~

~~feedstock.~~

~~24.——The system according to any of claim 15 to claim 23, wherein the ratio of hydrogen gas to the volume of catalyst bed in the reactor is in the range of 3, 20, 40, 50, 100, 150, 200, 250, 300, 350, 400, 500, 600, 700, 800 or 900 Nm³/m³, and/or the ratio of hydrogen gas to the renewable feedstock is in the range of about 10 to about 450 Nm³/m³/hr (about 0.001 to about 0.035 g/g/hr), about 10 to about 400 Nm³/m³/hr (about 0.001 to about 0.032 g/g/hr), about 10 to about 380 Nm³/m³/hr (about 0.001 to about 0.030 g/g/hr), about 10 to about 350 Nm³/m³/hr (about 0.001 to about 0.028 g/g/hr) or about 10 to about 320 Nm³/m³/hr (about 0.001 to about 0.025 g/g/hr).~~

~~25.——The system according to claim 15, wherein the catalyst comprises at least one of two transition metals selected from the group consisting of Ni and Mo.~~

~~26.——The system according to claim 25, wherein the catalyst further comprises another transition metal or a group V element, and/or the catalyst is loaded on a support.~~

~~27.——The system according to claim 26, wherein the support is an acidic porous solid support selected from the group comprising alumina (Al₂O₃), silica (SiO₂) and a mixture of alumina and silica (Al₂O₃-SiO₂).~~

~~28.——The system according to claim 26, wherein the support is fluoride alumina, ZSM 12, ZSM 21, ZSM 22, ZSM 23, ZSM 32, ZSM 35, ZSM 38, ZSM 48, ZSM 57, SAPO 11, SAPO 31, SAPO 41, MAPO 11, MAPO 31, zeolite Y, zeolite L or β zeolite.~~