

WHAT IS CLAIMED

- 1) A process comprising contacting a hydroprocessing catalyst with pyrolysis oil and hydrogen at temperatures lower than 300°C in the presence of at least one alcohol, wherein said hydroprocessing catalyst contains at least one Group VIII metal and at least one Group VIB metal and wherein said at least one alcohol is selected from i) an alcohol containing from 4 to 9 carbon atoms, or ii) a mixture of at least one first and at least one second alcohol having the same or a different number of carbon atoms wherein said at least one first alcohol contains from 4 to 9 carbon atoms and said at least one second alcohol contains in the range of from about 1 to about 15 carbon atoms.
- 2) The process according to claim 1 wherein said hydroprocessing catalyst is selected from bulk or supported hydroprocessing catalysts.
- 3) The process according to claim 2 wherein said supported catalysts comprise a support selected from silica, alumina, or silica/alumina, carbon, activated carbon, MgO, TiO₂ and ZrO₂, support.
- 4) The process according to claim 2 wherein said supported catalysts comprise a support consisting essentially of alumina.
- 5) The process according to any of claims 2-4 wherein said supported catalyst further comprises at least one promoter and/or said bulk catalyst further comprises a Group V metal component.
- 6) The process according to claim 5 wherein said at least one promoter is selected from F, K, Si, B, P, or combinations thereof, wherein said at least one promoter is deposited on the surface of the support, present within the catalyst support, or both.
- 7) The process according to claim 2 wherein said at least one Group VIII metal is selected from Fe, Co, Ni, and combinations thereof, and said at least one Group VIB metal, is selected from Mo, W, and combinations thereof.

- 8) The process according to claim 3 wherein said at least one Group VIII metal is selected from Co, Ni, or combinations thereof, and said at least one Group VIB metal is selected from Mo, W, and mixtures thereof.
- 9) The process according to claim 4 wherein said supported catalyst comprises Ni and Mo.
- 10) The process according to claim 6 wherein said supported catalyst comprises at least one Group VIII metal present in an amount ranging from about 0.5 to about 20 wt.% and at least one Group VIB metal present in an amount ranging from about 2 to about 50 wt.%.
- 11) The process according to claim 8 wherein said supported catalyst comprises at least one Group VIII metal present in an amount ranging from about 2 to about 8 wt.% and at least one Group VIB metal present in an amount ranging from about 10 to about 40 wt.%.
- 12) The process according to claim 9 wherein said supported catalyst comprises at least one Group VIII metal present in an amount ranging from about 3 to about 6 wt.% and at least one Group VIB metal present in an amount ranging from about 15 to about 30 wt.%.
- 13) The process according to any of the preceding claims wherein said at least one alcohol is isobutanol.
- 14) The process according to claim 2 wherein said temperatures are i) in the range of from about 40°C to about 300°C; ii) in the range of from about 100°C to about 300°C; or iii) in the range of from about 160°C to about 290°C.
- 15) The process according to claim 2 wherein said process comprises a first hydroprocessing stage and at least one additional hydroprocessing stage.
- 16) The process according to claim 15 wherein the temperatures of said second hydroprocessing stage are higher than those used in the first hydroprocessing stage.
- 17) The process according to claim 1 wherein said at least one alcohol is i).
- 18) The process according to claim 1 wherein said at least one alcohol is ii).
- 19) The process according to claim 18 wherein said at least one first alcohol and said at least one second alcohol have a different number of carbon atoms.

- 20) The process according to claim 18 wherein said at least one first alcohol and said at least one second alcohol have the same number of carbon atoms.
- 21) The process according to claim 13 wherein said hydroprocessing product further comprises isobutane, and said isobutane is optionally recovered.
- 22) A process comprising:
- a) contacting a bulk or supported hydroprocessing catalyst with pyrolysis oil and hydrogen at temperatures in the range of from about 40°C to about 300°C in the presence of at least one alcohol thereby producing at least a hydroprocessing product, which comprises at least water, at least a portion of the at least one alcohol, and products;
 - b) recovering at least a portion of said products from said hydroprocessing product; and,
 - c) recycling i) at least a portion of the hydroprocessing product, ii) at least a portion of any hydrogen, iii) at least a portion of the at least one alcohol; iv) at least a portion of the products; or v) any combination of i)- iv),
- wherein said hydroprocessing catalyst contains at least one Group VIII metal and at least one Group VIB metal, and wherein said at least one alcohol is selected from i) at least one alcohol containing from 4 to 9 carbon atoms, or ii) a mixture of at least one first and at least one second alcohol having the same or a different number of carbon atoms wherein said at least one first alcohol contains from 4 to 9 carbon atoms and said at least one second alcohol contains in the range of from about 1 to about 15 carbon atoms
- 23) The process according to claim 22 wherein said hydroprocessing catalyst is selected from supported hydroprocessing catalysts containing in the range of from about 0.5 to about 20 wt.% of said at least one Group VIII metal and in the range of from about 2 to about 50 wt.% of said at least one Group VIB metal, wherein said at least one Group VIII metal is selected from Fe, Co, Ni, and combinations thereof, and said at least one Group VIB metal, is selected from Mo, W, and combinations thereof.
- 24) The process according to claim 23 wherein said supported catalysts comprise a support selected from silica, alumina, or silica-alumina, carbon, activated carbon, MgO, TiO₂ and ZrO₂, support.

- 25) The process according to claim 23 wherein said supported catalysts comprise a support consisting essentially of alumina.
- 26) The process according to claim 23 wherein said supported catalyst further comprises at least one promoter selected from F, K, Si, B, P, or combinations thereof, wherein said at least one promoter is deposited on the surface of the support, present within the catalyst support, or both.
- 27) The process according to claim 26 wherein said hydroprocessing catalyst is a supported catalyst that comprises in the range of from about 2 to about 8 wt.% of at least one Group VIII metal selected from Co, Ni, or combinations thereof, and in the range of from about 10 to about 40 wt.% of at least one Group VIB metal selected from Mo, W, and mixtures thereof.
- 28) The process according to claim 25 wherein said hydroprocessing catalyst is a supported catalyst that comprises in the range of from about 3 to about 6 wt.% of Ni and in the range of from about 15 to about 30 wt.% Mo.
- 29) The process according to claim 28 wherein said at least one alcohol is isobutanol.
- 30) The process according to claim 29 wherein said temperatures are in the range of from about 100°C to about 300°C; or iii) in the range of from about 160°C to about 290°C.
- 31) The process according to claim 22 wherein said process comprises a first hydroprocessing stage and at least one additional hydroprocessing stage wherein the temperatures of said second hydroprocessing stage are higher than those used in the first hydroprocessing stage.
- 32) The process according to claim 22 wherein said at least one alcohol is ii) and said at least one second alcohol has a different number of carbon atoms than said at least one first alcohol.
- 33) The process according to claim 22 wherein said at least a portion of said products are recovered by removing at least a portion of said water from said hydroprocessing product by allowing or causing said hydroprocessing product to separate into at least an organic phase and an aqueous phase, and the aqueous phase is removed or the organic phase recovered, and then further processing said organic phase and/or said aqueous phase, to recover any products present therein.

- 34) The process according to claim 22 wherein said products contain less than about 20wt.% oxygen, based on the total weight of the product.
- 35) The process according to any of claims 22 or 33 wherein said recycling is conducted to any one or more point(s) in the process.
- 36) The process according to claim 35 wherein said recycling is i) recycled directly to the hydroprocessing reactor; ii) combined or mixed with the feed to the hydroprocessing reactor; iii) recycled to a heat exchanger to recover the heat value therefrom; iv) or separated or divided and introduced to any combination of i)- iv).
- 37) The process according to claim 31 wherein said recycling is i) recycled directly to the first or second hydroprocessing reactor; ii) combined or mixed with the feed to the first or second hydroprocessing reactor; iii) recycled to a heat exchanger to recover the heat value therefrom; iv) or separated or divided and introduced to any combination of i)- iv).
- 38) The process according to claim 29 wherein said hydroprocessing product further comprises isobutane, and said isobutane is optionally recovered.
- 39) A process comprising:
- contacting a supported hydroprocessing catalyst with pyrolysis oil and hydrogen at temperatures in the range of from about 40°C to about 300°C in the presence of at least alcohol thereby producing at least a hydroprocessing product, which comprises at least water, at least a portion of the at least one first alcohol, and products;
 - recovering at least a portion of said products from said hydroprocessing product; and,
 - recycling i) at least a portion of the hydroprocessing product, ii) at least a portion of any hydrogen, iii) at least a portion of the at least one alcohol; at least a portion of the products; or v) any combination of i)- iv),
- wherein said hydroprocessing catalyst contains in the range of from about 0.5 to about 20 wt.% of said at least one Group VIII metal and in the range of from about 2 to about 50 wt.% of said at least one Group VIB metal, wherein said at least one Group VIII metal is selected from Fe, Co, Ni, and combinations thereof, and said at least one Group VIB metal, is selected from Mo, W, and combinations

thereof and said support is selected from silica, alumina, or silica-alumina, carbon, activated carbon, MgO, TiO₂ and ZrO₂ support; and wherein said at least one alcohol is selected from i) at least one alcohol containing from 4 to 9 carbon atoms, or ii) a mixture of at least one first and at least one second alcohol having the same or a different number of carbon atoms wherein said at least one first alcohol contains from 4 to 9 carbon atoms and said at least one second alcohol contains in the range of from about 1 to about 15 carbon atoms

- 40) The process according to claim 39 wherein said supported catalysts comprise a support consisting essentially of alumina.
- 41) The process according to claim 39 wherein said supported catalyst further comprises at least one promoter selected from F, K, Si, B, P, or combinations thereof, wherein said at least one promoter is deposited on the surface of the support, present within the catalyst support, or both.
- 42) The process according to claim 41 wherein said hydroprocessing catalyst is a supported catalyst that comprises in the range of from about 2 to about 8 wt.% of at least one Group VIII metal selected from Co, Ni, or combinations thereof, and in the range of from about 10 to about 40 wt.% of at least one Group VIB metal is selected from Mo, W, and mixtures thereof.
- 43) The process according to claim 40 wherein said hydroprocessing catalyst is a supported catalyst that comprises in the range of from about 3 to about 6 wt.% of Ni and in the range of from about 15 to about 30 wt.% Mo.
- 44) The process according to claim 43 wherein said at least one alcohol is isobutanol.
- 45) The process according to claim 42 wherein said temperatures are in the range of from about 100°C to about 300°C or in the range of from about 160°C to about 290°C.
- 46) The process according to claim 39 wherein said process comprises a first hydroprocessing stage and at least one additional hydroprocessing stage wherein the temperatures of said second hydroprocessing stage are higher than those used in the first hydroprocessing stage.
- 47) The process according to claim 39 wherein said at least one alcohol is ii) and said at least one second alcohol has a different number of carbon atoms than said at least one first alcohol.

- 48) The process according to claim 45 wherein said at least a portion of said products are recovered by removing at least a portion of said water from said hydroprocessing product by allowing or causing said hydroprocessing product to separate into at least an organic phase and an aqueous phase, and the aqueous phase is removed or the organic phase recovered, and then further processing said organic phase and/or said aqueous phase, to recover any products present therein.
- 49) The process according to claim 48 wherein said products contain less than about 20wt.% oxygen, based on the total weight of the product.
- 50) The process according claim 46 wherein said recycling is i) recycled directly to the first or second hydroprocessing reactor; ii) combined or mixed with the feed to the first or second hydroprocessing reactor; iii) recycled to a heat exchanger to recover the heat value therefrom; iv) or separated or divided and introduced to any combination of i)- iv).
- 51) The process according to claim 39 wherein said recycling is i) recycled directly to the hydroprocessing reactor; ii) combined or mixed with the feed to the hydroprocessing reactor; iii) recycled to a heat exchanger to recover the heat value therefrom; iv) or separated or divided and introduced to any combination of i)- iv).
- 52) The process according to claim 44 wherein said hydroprocessing product further comprises isobutane, and said isobutane is optionally recovered.

What is claimed is:

[Claim 1]

A process, comprising:

reacting a hydrotreating catalyst with a pyrolytic oil and hydrogen at a temperature lower than 300°C in the presence of at least one added alcohol; wherein

the hydrotreating catalyst contains at least one group VIII metal and at least one group VIB metal, the at least one added alcohol is selected from a mixture of i) alcohol containing 4 to 9 carbon atoms, or ii) at least one of a first alcohol and at least one of second alcohol having the same or a different number of carbon atoms, the at least one first alcohol containing 4 to 9 atoms, and the at least one second alcohol containing a range of 1 to 15 carbon atoms.

[Claim 2]

The process according to claim 1, wherein the hydrotreating catalyst is selected from a bulk hydrotreating catalyst or supported hydrotreating catalyst.

[Claim 3]

The process according to claim 2, wherein the hydrogenated supported catalyst contains a silica support medium, alumina support medium, or a support medium selected from a silica-alumina support medium, carbon support medium, activated carbon support medium, MgO support medium, TiO₂ support medium, and ZrO₂ support medium.

[Claim 4]

The process according to claim 2, wherein the hydrogenated supported catalyst contains a support medium fundamentally composed of alumina.

[Claim 5]

The process according to claims 2 to 4, wherein the hydrogenated supported catalyst further contains at least one promoter, and/or the bulk catalyst further comprises a group V metal component.

[Claim 6]

The process according to claim 2, wherein the hydrogenated supported catalyst contains at least one group VIII metal in an amount ranging from 0.5 to 20 weight percent, and at least one group VIB metal in an amount ranging from 2 to 50 weight percent.

[Claim 7]

The process according to claim 1, wherein the at least one added alcohol is isobutanol.

[Claim 8]

A process, comprising:

a) reacting a bulk hydrotreating catalyst or a supported hydrotreating catalyst with a pyrolytic oil and hydrogen at a temperature ranging from 40°C to 300°C in the presence of at least one added alcohol, thereby generating at least a hydrotreated product containing at least water, at least part of the at least one added alcohol, and a product;

b) recovering at least part of the product from the hydrotreated product;

c) recirculating i) at least part of the hydrotreated product, ii) at least part of an appropriate hydrogen, iii) at least part of the at least one added alcohol, iv) at least part of the product, or v) an appropriate combination of i) to iv); wherein

the hydrotreating catalyst contains at least one group VIII metal and at least one group VIB metal, and the at least one added alcohol is selected from a mixture of i) at least one alcohol containing 4 to 9 carbon atoms, or ii) at least one of a first alcohol and at least one of a second alcohol having the same or a different number of carbon atoms, wherein the at least one first alcohol contains 4 to 9 atoms, and the at least one second alcohol contains a range of 1 to 15 carbon atoms.

[Claim 9]

The process according to claim 8, wherein the hydrotreating catalyst is selected from a supported hydrotreating catalyst containing the at least one group VIII metal in a range of 0.5 to 20 weight percent and a supported hydrotreating catalyst containing the at least one group VIB metal in a range of 2 to 50 weight percent, the at least one group III metal is selected from Fe, Co, Ni, and a combination thereof, and the at least one group VIB metal is selected from Mo, W, and a combination thereof.

[Claim 10]

The process according to claim 9, wherein the hydrogenated supported catalyst contains a silica support medium, alumina support medium, or a support medium selected from a silica-alumina support medium, carbon support medium, activated carbon support medium, MgO support medium, TiO₂ support medium, and ZrO₂ support medium.

[Claim 11]

A process, comprising:

a) reacting a bulk hydrotreating catalyst or a supported hydrotreating catalyst with a pyrolytic oil and hydrogen at a temperature ranging from 40°C to 300°C in the presence of at least one added alcohol, and thereby generating at least a hydrotreated product containing at least water, at least part of the at least one added alcohol, and a product;

b) recovering at least part of the product from the hydrotreated product;

c) recirculating i) at least part of the hydrotreated product, ii) at least part of an appropriate hydrogen, iii) at least part of the at least one added alcohol, iv) at least part of the product, or v) an appropriate combination of i) to iv); wherein

the hydrotreating catalyst contains at least one group VIII metal in a range from 0.5 to 20 weight percent and at least one group VIB metal in a range from 2 to 50 weight percent, the at least one group VIII metal is selected from Fe, Co, Ni, and a combination thereof, the at least one group VIB metal is selected from Mo, W, and a combination thereof, the support medium is selected from a silica support medium, alumina support medium, or a silica-alumina support medium, carbon support medium, activated carbon support medium, MgO support medium, TiO₂ support medium, and ZrO₂ support medium, and the at least one added alcohol is selected from a mixture of i) at least one alcohol containing 4 to 9 carbon atoms, or ii) at least one of a first alcohol and at least one of a second alcohol having the same or a different number of carbon atoms, wherein the at least one first alcohol contains 4 to 9 atoms, and the at least one second alcohol contains a range of 1 to 15 carbon atoms.

[Claim 12]

The process according to claim 11, wherein the hydrogenated supported catalyst contains a support medium fundamentally composed alumina.

[Claim 13]

The process according to claim 11, wherein the hydrogenated supported catalyst further contains at least one promoter selected from F, K, Si, B, P, or a combination thereof, wherein the at least one promoter is deposited on the surface of the support medium, exists within the support medium, or both.

[Claim 14]

The process according to claim 11, wherein the process contains a first hydrotreating step and at least one further hydrotreating step, and the temperature of the second hydrotreating step is higher than the temperature used in the first hydrotreating step.