CLAIMS

1. A method of producing a supported catalyst, the method comprising:

(a) combining a porous inorganic oxide catalyst carrier or carrier extrudate with an aqueous solution, dispersion or suspension comprising:

(i) a boron-containing source; and

(ii) an organic compound or organic chelating agent selected from organic compounds comprising at least two oxygen atoms and 2-10 carbon atoms;

to form a boron and organic compound-containing carrier composition and optionally extruding the composition to form an extrudate;

(b) calcining, or drying and calcining the composition or extrudate formed in (a) to reduce its volatiles content to a level of greater than 0 wt% to 5 wt%, as measured by Loss on Ignition (LOI);

(c) impregnating the calcined composition formed in (b) with a solution, dispersion or suspension comprising at least one Group VIB metal-containing component or source and at least one Group VIIIB metal-containing component or source; and

(d) calcining, or drying and calcining the composition formed pursuant to impregnating step (c) to reduce its volatiles content to a level as measured by Loss on Ignition (LOI) of greater than 0 wt% to less than 30 wt%;

wherein

(1) the amount of boron-containing source is sufficient to form a supported catalyst having a boron content in the range of 1 wt% to 13 wt%, expressed as boron oxide, B_2O_3, and based on the total weight of the catalyst; and

(2) Loss on Ignition (LOI) is measured by subjecting a weighed sample to an oxygen-containing atmosphere for l hour at 1020°F (548.9 °C) and measuring the loss in weight of the sample.

2. The method according to claim 1, wherein the boron content of the supported catalyst produced is in the range of 1.5 wt% to 6 wt%, expressed as boron oxide, B_2O_3, and based on the total weight of the catalyst.

3. The method according to claim 1 or claim 2, wherein the boron content of the supported catalyst produced is in the range of 2 wt% to 5 wt%, expressed as boron oxide, B_2O_3, and based on the total weight of the catalyst.

4. The method according to any one of claims 1 to 3, wherein the solution, dispersion or suspension in step (c) further comprises a phosphorus-containing source to provide a phosphorus content of the supported catalyst of 0.5 wt% to 10 wt%, expressed as an oxide, P_2O_5, and based on the total weight of the catalyst.

5. The method according to claim 4, wherein the amount of the phosphorus-containing source results in a phosphorus content of the supported catalyst in the range of 0.5 wt% to 5 wt% or 4 wt% to 10 wt%, expressed as an oxide, P_2O_5, and based on the total weight of the catalyst.

6. The method according to any one of claims 1-5, wherein the boron-containing source is selected from meta-boric acid (HBO_2), ortho-boric acid (H_3BO_3), ammonium borate tetra-hydrate [$(NH_4)2B_4O_7.4H_2O$], sodium tetra borate, ammonium borate, ammonium tetra borate [$(NH_4)_2B_4O_7$], boric oxide (B_2O_3), lithium tetraborate, mono-, di- or tri-alkyl amine borate, ammonium tetra phenyl borate, organic boron compounds and mixtures thereof.

7. The method according to any one of claims 1-6, wherein the organic compound or chelate is selected from organic compounds comprising at least two oxygen atoms and 2-10 carbon atoms, and the ethers, esters, acetals, acid chlorides, acid amides, oligomers or polymers thereof, and/or (ii) an organic compound comprising at least one covalently bonded nitrogen atom and at least one carbonyl moiety.

8. The method according to any one of claims 1-7, wherein the organic compound is selected from acetic acid, citric acid, tartaric acid, oxalic acid, maleic acid, malonic acid, malic acid, butanediol, pyruvic aldehyde, glycol aldehyde, acetaldol, tartaric acid, ethylene glycol, propylene glycol, glycerin, trimethylol ethane, trimethylol propane,

diethylene glycol, dipropylene glycol, trimethylene glycol, triethylene glycol, tributylene glycol, tetraethylene glycol, tetrapentylene glycol, polyethylene glycol, ethylene glycol monobutyl ether, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, diethylene glycol monopropyl ether, and diethylene glycol monobutyl ether and mixtures thereof.

9. The method according to any one of claims 1-8, wherein the boron source comprises boric acid and the organic compound comprises citric acid.

10. The method according to any one of claims 1-9, wherein the solution, dispersion or suspension in step (c) comprises at least one organic chelating agent selected from: (i) an organic compound comprising at least two oxygen atoms and 2-10 carbon atoms, and the ethers, esters, acetals, acid chlorides, acid amides, oligomers or polymers thereof; and/or (ii) an organic compound comprising at least one covalently bonded nitrogen atom and at least one carbonyl moiety.

11. The method according to claim 10, comprising an organic chelating agent selected from acetic acid, citric acid, oxalic acid, maleic acid, malonic acid, malic acid, ethylene glycol and ammonium bicarbonate.

12. The method according to any one of claims 1-11, wherein the Loss on Ignition after step (b) is greater than 0 and to 2 wt%.

13. The method according to any one of claims 1-12, wherein the catalyst exhibits a Loss on Ignition after step (d) of from 3 to 7 wt%.

14. The method according to any one of claims 1-13 wherein the porous inorganic oxide is selected from eta-, theta-, or gamma alumina and mixtures thereof, silica, silica-alumina, alumina with silica-alumina dispersed therein, silica-coated alumina, alumina-coated silica, magnesia, zirconia, titania, titania-alumina, and mixtures thereof.

15. A supported catalyst formed in accordance with the method according to any one of claims 1-14.

16. A method which comprises contacting a hydrocarbon feed with the supported catalyst according to claim 15, under hydrotreating conditions so as to hydrotreat the hydrocarbon feed.

17. A method of producing an inorganic oxide catalyst support, the method comprising:

(a) combining a porous inorganic oxide in particulate form with a composition comprising an aqueous solution, dispersion, or suspension comprising:

(1) a boron-containing source; and

(2) an organic compound selected from the group consisting of compounds comprising at least two oxygen atoms and 2-10 carbon atoms; and

(b) extruding the combination in (a) to form an extrudate;

(c) calcining or drying and calcining the extrudate to a dryness level measured by Loss on Ignition (LOI) of greater than 0 wt% to 5 wt%;

wherein:

(i) the boron-containing source is present in an amount to provide a boron content in the range of 1 wt% to 13 wt%, expressed as boron oxide, B_2O_3 and based on the total weight of the support; and

(ii) Loss on Ignition is measured by subjecting a weighed sample to an oxygen-containing atmosphere for l hour at 1020 of (548.9 °C) and measuring the loss in weight.

18. The method according to claim 17, wherein the boron content of the support is in the range of 1.5 wt% to 6 wt%, expressed as an oxide, B_2O_3, and based on the total weight of the support.

19. The method according to claim 18, wherein the boron content of the catalyst support is in the range of 2 wt% to 5 wt%, expressed as an oxide, B_2O_3, and based on the total weight of the support.

20. The method according to any of claims 17-19, wherein in step (a):

(1) the boron-containing source is selected from meta-boric acid (HBO_2), ortho-boric acid (H_3BO_3), ammonium borate tetra-hydrate [$(NH_4)2B_4O_7.4H_2O$], sodium tetra borate, ammonium borate, ammonium tetra borate [$(NH_4)_2B_4O_7$], boric oxide (B_2O_3), lithium tetraborate, mono-, di- or tri-alkyl amine borate, ammonium tetra phenyl borate, organic boron compounds and mixtures thereof and the organic compound comprises citric acid; and

(2) the organic compound or chelate is selected from organic compounds comprising at least two oxygen atoms and 2-10 carbon atoms, and the ethers, esters, acetals, acid chlorides, acid amides, oligomers or polymers thereof, and/or (ii) an organic compound comprising at least one covalently bonded nitrogen atom and at least one carbonyl moiety.

21. The method according to any of claims 17-20, wherein in step (a) the boron-containing source comprises boric acid and the organic compound or chelate comprises citric acid.

22. The method according to any one of claims 17-21 wherein the porous inorganic oxide is selected from eta-, theta-, or gamma alumina and mixtures thereof, silica, silica-alumina, alumina with silica-alumina dispersed therein, silica-coated alumina, alumina-coated silica, magnesia, zirconia, titania, titania-alumina, and mixtures thereof.

23. A supported hydroprocessing catalyst comprising:

a porous inorganic oxide catalyst carrier or catalyst support;

at least one Group VIB metal component in the form of an oxide;

at least one Group VIIIB metal component in the form of an oxide;

a boron-containing component in the form of an oxide, expressed as B_2O_3; and

optionally a phosphorus component in the form of an oxide, expressed as P_2O_5; and

wherein:

(a) the content of boron oxide is in the range of 1 to 13 wt%, based on the total weight of the catalyst;

(b) the content of the phosphorus component, when present, is at least 0.5 wt %, based on the total weight of the catalyst, and

wherein:

(1) the Group VIB and Group VIIIB metal components and phosphorus component and boron component are supported on and/or in a support or carrier comprising alumina or silica in the form of a pill having an internal cross-section and an outer surface; and

(2) a position across the internal cross-section of the pill is identified by a percentage of the distance following a centerline from a first edge of the pill cross-section, designated as the starting point or 0% to the furthest edge of the pill cross-section, designated as 100%, along the centerline; and

wherein:

(I) the concentration of the Group VIB metal oxide in the first 33⅓ % or the last 33⅓% of the pill cross-section exceeds the concentration of the Group VIB metal oxide in the central 33⅓% of the pill cross-section by from 20% to 100%; and

(II) the concentration of the Group VIB and Group VIIIB metal oxide components and phosphorus oxide component when present, across the cross section to the outer surface of the pill is determined using electron probe microanalysis.

24. The catalyst according to claim 23 wherein the Group VIB metal component is selected from an oxide of molybdenum tungsten or chromium.

25. The catalyst according to claim 23 or 24 wherein the Group VIIIB metal component is selected from an oxide of cobalt or nickel.

26. The catalyst according to any one of claims 23 to 25, wherein the Group VIB metal component comprises molybdenum or tungsten.

27. The catalyst according to any one of claims 23 to 26 comprising phosphorus.

28. The catalyst according to claim 27 wherein the concentration of the phosphorus oxide in the first 33⅓ % or the last 33⅓ % of the pill cross-section exceeds the concentration of the phosphorus oxide in the central 33⅓ of the pill cross-section by from 30% to 350%.

29. The catalyst according to claim 27 or 28 wherein the amount of the phosphorus component is in the range of 4 wt% to 10 wt%, expressed as an oxide, P_2O_5, and based on the total weight of the catalyst.

30. The catalyst according to claim 29, wherein the amount of the phosphorus component is in the range of 4 wt% to 7 wt%.

31. The catalyst according to claim 30, wherein the boron content in the range of 2 wt% to 8 wt%, expressed as an oxide, B_2O_3, and based on the total weight of the catalyst.

32. The catalyst according to claim 31, wherein the boron content in the range of 4 wt% to 6 wt%.

33. The catalyst according to any one of claims 23 to 32, wherein the carrier comprises alumina.

34. The catalyst according to any one of claims 23 to 33, wherein the boron source comprises boric acid.

35. The catalyst according to any one of claims 23 to 34, further comprising an organic additive.

36. The catalyst according to claim 35, wherein the organic additive is selected from: (i) an organic compound comprising at least two oxygen atoms and 2 - 10 carbon atoms, and the ethers, esters, acetals, acid chlorides, acid amides, oligomers or polymers thereof;

and/or (ii) an organic compound comprising at least one covalently bonded nitrogen atom and at least one carbonyl moiety.

37. The catalyst according to any one of the preceding claims wherein the porous inorganic oxide is selected from eta-, theta-, or gamma alumina and mixtures thereof, silica, silica-alumina, alumina with silica-alumina dispersed therein, silica-coated alumina, alumina-coated silica, magnesia, zirconia, titania, titania-alumina, and mixtures thereof.