

CLAIMS:

1. A process for preparing a slurry catalyst composition for use in the upgrade of heavy oil feedstock, comprising:

providing at least an inorganic metal precursor comprising at least a Primary metal
5 selected from Group VIB metals, Group IIB metals and Group VIII metals;

mixing at least a polar aprotic solvent with the inorganic metal precursor to form an oil-dispersible inorganic metal precursor, at a weight ratio of solvent to inorganic metal precursor of 1:1 to 10:1;

providing at least a sulfiding agent to sulfide the oil-dispersible inorganic metal
10 precursor forming the slurry catalyst.

2. The process of claim 1, further comprising:
subjecting the oil-dispersible inorganic metal precursor to a reduction step for the Primary metal to change its oxidation state.

3. The process of any of claims 1 - 2, wherein the mixing of the polar aprotic solvent with the inorganic metal precursor is under high shear mixing forming to generate an emulsion with droplet sizes ranging from 0.1 to 300 μm .

4. The process of any of claims 1 - 2, wherein the weight ratio of solvent to inorganic metal precursor ranges from 2:1 to 5:1.

5. The process of any of claims 1 - 2, wherein the oil-dispersible inorganic metal precursor is mixed with a hydrocarbon diluent comprising a heavy oil feedstock for the heavy oil feedstock to provide the sulfiding agent needed to sulfide the oil-dispersible inorganic metal precursor.

6. The process of any of claims 1 - 2, wherein the oil-dispersible inorganic metal precursor is mixed with a hydrocarbon diluent containing the heavy oil feedstock at a temperature from 752°F to 1112°F under a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

7. The process of any of claims 1 - 2, wherein the slurry catalyst prepared thereof has the formula $(M^t)_a(L^u)_b(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h$, wherein M is the Primary metal and

selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

8. The process of any of claims 1 - 2, wherein the sulfiding agent is selected from the group of elemental sulfur, hydrogen sulfide, ammonium sulfide, ammonium polysulfide $((\text{NH}_4)_2\text{S}_x)$, ammonium thiosulfate $((\text{NH}_4)_2\text{S}_2\text{O}_3)$, sodium thiosulfate $(\text{Na}_2\text{S}_2\text{O}_3)$, thiourea (CSN_2H_4) , carbon disulfide, dimethyl disulfide (DMDS), dimethyl sulfide (DMS), tertiarybutyl polysulfide (PSTB) and tertiarynonyl polysulfide (PSTN), and mixtures thereof.

9. The process of any of claims 1 - 2, further comprising the step of mixing the slurry catalyst with a heavy oil feedstock for heavy oil upgrade.

10. The process of any of claims 1 - 2, further comprising the step of mixing the oil-dispersible inorganic metal precursor with a hydrocarbon diluent prior to the sulfiding step.

11. The process of any of claims 1 - 2, wherein the sulfiding is in-situ upon contact with a heavy oil feedstock under hydroprocessing conditions for the heavy oil feedstock to provide the at least a sulfiding agent to sulfide the oil-dispersible inorganic metal precursor.

12. The process of any of claims 1 - 2, wherein the polar aprotic solvent is selected from the group of N-Methylpyrrolidone (NMP), dimethylformamide (DMF), dimethylacetamide (DMAC), hexamethylphosphortriamide (HMPA), dimethyl sulfoxide (DMSO), tetrahydrofuran, propylene carbonate, dimethyl sulfite, N-nitrosodimethylamine, γ -butyrolactone, N:N dimethyl formamide, dimethyl carbonate, methyl formate, butyl formate and mixtures thereof.

13. The process of any of claims 1 - 2, wherein the polar aprotic solvent is used as neat liquid.

14. The process of any of claims 1 - 2, wherein the polar aprotic solvent is dimethyl sulfoxide (DMSO).

5 15. The process of any of claims 1 - 2, wherein the inorganic metal precursor is selected from the group of molybdenum oxide, molybdenum sulfide, molybdenum oxysulfide, molybdenum trioxide, ammonium heptamolybdate, and mixtures thereof.

10 16. The process of any of claims 1 - 2, wherein the at least an inorganic metal precursor feed comprising at least a Group VIB metal is selected from the group of molybdenum oxide, molybdenum sulfide, molybdenum oxysulfide, molybdenum trioxide, ammonium heptamolybdate, and mixtures thereof.

15 17. A process for preparing a slurry catalyst composition for use in the upgrade of heavy oil feedstock, comprising:

providing at least an inorganic metal precursor comprising at least a Primary metal selected from Group VIB metals and Group VIII metals;

20 providing at least an inorganic metal precursor comprising at least a Promoter metal selected from Group IVB metals, Group VIII metals, and Group IIB metals, wherein the Primary metal is different from the Promoter metal;

mixing at least a polar aprotic solvent with the inorganic metal precursors to form an oil-dispersible mixture, at a weight ratio of polar aprotic solvent to inorganic metal precursor feed of 1:1 to 10:1;

25 mixing the oil-dispersible mixture with a heavy oil feed under in-situ sulfidation conditions, forming the slurry catalyst.

18. The process of claim 17, wherein the weight ratio of polar aprotic solvent to the inorganic metal precursors ranges from 2:1 to 5:1.

30 19. The process of any of claims 17 - 18, wherein the oil-dispersible mixture is mixed with the heavy oil feed at a temperature from 752°F to 1112 °F under a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa) for in-situ sulfiding to take place.

20. The process of any of claims 17 - 18, wherein the slurry catalyst prepared therefrom has a total surface area of at least 100 m²/g.

21. The process of any of claims 17 - 18, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.4 cc/g and a polymodal pore distribution with at least 90% of pore sizes in the range of 5 to 1,000 Angstroms in diameter.

22. The process of any of claims 17 - 18, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.5 cc/g.

23. The process of any of claims 17 - 18, wherein the slurry catalyst prepared therefrom comprises a plurality of dispersed particles with the dispersed particles have an average particle size ranging from 1 to 300 μm.

24. The process of any of claims 17 - 18, wherein the polar aprotic solvent is selected from the group of N-Methylpyrrolidone (NMP), dimethylformamide (DMF), dimethylacetamide (DMAC), hexamethylphosphortriamide (HMPA), dimethyl sulfoxide (DMSO), tetrahydrofuran, propylene carbonate, dimethyl sulfite, N-nitrosodimethylamine, γ-butyrolactone, N:N dimethyl formamide, dimethyl carbonate, methyl formate, butyl formate and mixtures thereof.

25. The process of any of claims 17 - 18, wherein the polar aprotic solvent is dimethyl sulfoxide.

26. The process of any of claims 17 - 18, wherein the slurry catalyst prepared thereof has the formula (M^t)_a(L^u)_b(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h, wherein M is a Primary metal selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

27. The process of claim 1, wherein the hydrogen feed is mixed with the slurry catalyst for a sufficient amount of time for the slurry catalyst to have an increase in surface area of at least 10% compare to a slurry catalyst that is not mixed with the hydrogen feed.

5 28. The process of claim 27, wherein the hydrogen feed is mixed with the slurry catalyst for a sufficient amount of time for the slurry catalyst to have an increase in total pore volume of at least 10% compare to a slurry catalyst that is not mixed with the hydrogen feed.

10 29. The process of claim 27, wherein the slurry catalyst treated with hydrogen provides an increase of rate constant k-values in terms of HDS, HDN, and HDMCR of at least 15% compared to a slurry catalyst that is not treated with hydrogen.

15 30. The process of claim 27, wherein the hydrogen feed is mixed with the slurry catalyst in a transfer line prior to being fed to a hydrocracker for the upgrade of heavy oil feedstock.

31. The process of claim 27, wherein the hydrogen feed is mixed with the slurry catalyst in a pre-mixing vessel prior to being fed to a hydrocracker for the upgrade of heavy oil feedstock.

20 32. The process of claim 27, wherein the hydrogen feed is mixed with the slurry catalyst at a temperature of 350°F to 750°F.

25 33. The process of claim 27, wherein the hydrogen feed is mixed with the slurry catalyst for at least an hour.

34. The process of claim 27, wherein the hydrogen feed is mixed with the slurry catalyst for 2 to 5 hours.

30 35. The process of claim 27, wherein the slurry catalyst composition prepared therefrom has a total pore volume of at least 0.4 cc/g and a polymodal pore distribution with at least 70% of pore sizes in the range of 5 to 2,000 Angstroms in diameter.

36. The process of claim 27, wherein the slurry catalyst composition prepared therefrom has a total surface area of at least 100 m²/g.

37. The process of claim 27, wherein the slurry catalyst treated with hydrogen further provides an increase in surface area and total pore volume of at least 10% compared to a slurry catalyst that is not treated with hydrogen.

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38. The process of claim 37, wherein the slurry catalyst treated with hydrogen further provides an increase in surface area and total pore volume of at least 15% compared to a slurry catalyst that is not treated with hydrogen.

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39. The process of claim 27, wherein the slurry catalyst has the formula $(M^t)_a(L^u)_b(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h$, wherein M is a Primary metal selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

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40. The slurry catalyst of claim 16, wherein $b=0$, and the Primary metal M is nickel.

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41. The process of claim 1, wherein the mixing of the catalyst precursor with the hydrocarbon diluent is in the presence of a reducing agent and under reducing conditions.

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42. The process of claim 41, wherein the mixing of the catalyst precursor with the hydrocarbon diluent is under high shear mixing forming an emulsion having droplets with particle sizes ranging from 1 to 300 μm .

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43. The process of claim 41, wherein providing the at least a metal precursor comprising at least two different metal cations comprises combining and reacting at least a Group VIB metal compound with at least a Promoter metal compound selected from Group VIII, Group IIB, Group IIA, Group IVA metals and combinations thereof.

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44. The process of claim 43, wherein the at least one Group VIB metal compound is a water-soluble Group VIB metal salt in solution and the Promoter metal compound is a water-soluble Group VIII metal salt in solution.

45. The process of claim 44, wherein the water-soluble Group VIB metal salt in solution is selected from the group of ammonium dimolybdate, ammonium heptamolybdate, ammonium octamolybdate, potassium molybdate, potassium chromium sulfate, ammonium para-molybdate and mixtures thereof.

46. The process of claim 44, wherein the water-soluble Group VIII metal salt in solution is selected from the group of nickel sulfate, nickel ammonium sulfate, iron sulfate, and mixtures thereof.

47. The process of claim 43, wherein the Group VIB metal compound is an oil soluble molybdenum salt and the Promoter metal compound is an oil soluble Group VIII metal salt.

48. The process of claim 43, wherein the at least one Group VIB metal compound is ammonium dimolybdate and the Promoter metal compound is nickel sulfate.

49. The process of claim 41, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.4 cc/g.

50. The process of claim 41, wherein the slurry catalyst prepared therefrom has a polymodal pore distribution with at least 80% of pore sizes in the range of 5 to 2,000 Angstroms in diameter.

51. The process of claim 41, wherein the slurry catalyst prepared therefrom has polymodal pore distribution with at least at least 80% of the pore sizes are in the range of 5 to 1000 Angstroms in diameter.

52. The process of claim 41, wherein the slurry catalyst prepared therefrom has a total surface area of at least 100 m²/g.

53. The process of claim 41, wherein the slurry catalyst prepared therefrom has an average particle size ranging from 2 to 100 μm.

54. The process of claim 44, wherein the water-soluble Group VIB metal salt in solution has a concentration of 5 – 8 wt. % of Group VIB metal.

5 55. The process of claim 54, wherein the water-soluble Group VIB metal salt in solution has a pH of at least 4.

56. The process of claim 44, wherein the water-soluble Group VIII metal salt in solution has a pH of at least 4.

10 57. The process of claim 56, wherein the water-soluble Group VIII metal salt in solution has a concentration of 5 – 8 wt. % of Group VIB metal.

15 58. The process of claim 3, wherein the in-situ sulfiding condition is at a temperature from 752°F to 1112 °F and a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

59. The process of claim 5, wherein a sufficient amount of sulfiding agent is provided a molar ratio of sulfur to molybdenum of at least 1.5 to 1 to sulfide the emulsion to form the slurry catalyst.

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CLAIMS:

1. A process for preparing a slurry catalyst composition for use in the upgrade of heavy oil feedstock, comprising:

providing at least an inorganic metal precursor comprising at least a Primary metal
5 selected from Group VIB metals, Group IIB metals and Group VIII metals;

mixing at least a polar aprotic solvent with the inorganic metal precursor to form an oil-dispersible inorganic metal precursor, at a weight ratio of solvent to inorganic metal precursor of 1:1 to 10:1;

providing at least a sulfiding agent to sulfide the oil-dispersible inorganic metal
10 precursor forming the slurry catalyst.

2. The process of claim 1, further comprising:

subjecting the oil-dispersible inorganic metal precursor to a reduction step for the Primary metal to change its oxidation state.

3. The process of any of claims 1 - 2, wherein the mixing of the polar aprotic solvent with the inorganic metal precursor is under high shear mixing forming to generate an emulsion with droplet sizes ranging from 0.1 to 300 μm .

4. The process of any of claims 1 - 2, wherein the weight ratio of solvent to inorganic metal precursor ranges from 2:1 to 5:1.

5. The process of any of claims 1 - 2, wherein the oil-dispersible inorganic metal precursor is mixed with a hydrocarbon diluent comprising a heavy oil feedstock for the heavy oil feedstock to provide the sulfiding agent needed to sulfide the oil-dispersible inorganic metal precursor.

6. The process of any of claims 1 - 2, wherein the oil-dispersible inorganic metal precursor is mixed with a hydrocarbon diluent containing the heavy oil feedstock at a temperature from 752°F to 1112 °F under a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

7. The process of any of claims 1 - 2, wherein the slurry catalyst prepared thereof has the formula $(M^t)_a(L^u)_b(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h$, wherein M is the Primary metal and

selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

8. The process of any of claims 1 - 2, wherein the sulfiding agent is selected from the group of elemental sulfur, hydrogen sulfide, ammonium sulfide, ammonium polysulfide $((\text{NH}_4)_2\text{S}_x)$, ammonium thiosulfate $((\text{NH}_4)_2\text{S}_2\text{O}_3)$, sodium thiosulfate $(\text{Na}_2\text{S}_2\text{O}_3)$, thiourea (CSN_2H_4) , carbon disulfide, dimethyl disulfide (DMDS), dimethyl sulfide (DMS), tertiarybutyl polysulfide (PSTB) and tertiarynonyl polysulfide (PSTN), and mixtures thereof.

9. The process of any of claims 1 - 2, further comprising the step of mixing the slurry catalyst with a heavy oil feedstock for heavy oil upgrade.

10. The process of any of claims 1 - 2, further comprising the step of mixing the oil-dispersible inorganic metal precursor with a hydrocarbon diluent prior to the sulfiding step.

11. The process of any of claims 1 - 2, wherein the sulfiding is in-situ upon contact with a heavy oil feedstock under hydroprocessing conditions for the heavy oil feedstock to provide the at least a sulfiding agent to sulfide the oil-dispersible inorganic metal precursor.

12. The process of any of claims 1 - 2, wherein the polar aprotic solvent is selected from the group of N-Methylpyrrolidone (NMP), dimethylformamide (DMF), dimethylacetamide (DMAC), hexamethylphosphortriamide (HMPA), dimethyl sulfoxide (DMSO), tetrahydrofuran, propylene carbonate, dimethyl sulfite, N-nitrosodimethylamine, γ -butyrolactone, N,N dimethyl formamide, dimethyl carbonate, methyl formate, butyl formate and mixtures thereof.

13. The process of any of claims 1 - 2, wherein the polar aprotic solvent is used as neat liquid.

14. The process of any of claims 1 - 2, wherein the polar aprotic solvent is dimethyl sulfoxide (DMSO).

5 15. The process of any of claims 1 - 2, wherein the inorganic metal precursor is selected from the group of molybdenum oxide, molybdenum sulfide, molybdenum oxysulfide, molybdenum trioxide, ammonium heptamolybdate, and mixtures thereof.

10 16. The process of any of claims 1 - 2, wherein the at least an inorganic metal precursor feed comprising at least a Group VIB metal is selected from the group of molybdenum oxide, molybdenum sulfide, molybdenum oxysulfide, molybdenum trioxide, ammonium heptamolybdate, and mixtures thereof.

15 17. A process for preparing a slurry catalyst composition for use in the upgrade of heavy oil feedstock, comprising:

providing at least an inorganic metal precursor comprising at least a Primary metal selected from Group VIB metals and Group VIII metals;

20 providing at least an inorganic metal precursor comprising at least a Promoter metal selected from Group IVB metals, Group VIII metals, and Group IIB metals, wherein the Primary metal is different from the Promoter metal;

mixing at least a polar aprotic solvent with the inorganic metal precursors to form an oil-dispersible mixture, at a weight ratio of polar aprotic solvent to inorganic metal precursor feed of 1:1 to 10:1;

25 mixing the oil-dispersible mixture with a heavy oil feed under in-situ sulfidation conditions, forming the slurry catalyst.

18. The process of claim 17, wherein the weight ratio of polar aprotic solvent to the inorganic metal precursors ranges from 2:1 to 5:1.

30 19. The process of any of claims 17 - 18, wherein the oil-dispersible mixture is mixed with the heavy oil feed at a temperature from 752°F to 1112°F under a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa) for in-situ sulfiding to take place.

20. The process of any of claims 17 - 18, wherein the slurry catalyst prepared therefrom has a total surface area of at least 100 m²/g.

21. The process of any of claims 17 - 18, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.4 cc/g and a polymodal pore distribution with at least 90% of pore sizes in the range of 5 to 1,000 Angstroms in diameter.

22. The process of any of claims 17 - 18, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.5 cc/g.

23. The process of any of claims 17 - 18, wherein the slurry catalyst prepared therefrom comprises a plurality of dispersed particles with the dispersed particles have an average particle size ranging from 1 to 300 μm.

24. The process of any of claims 17 - 18, wherein the polar aprotic solvent is selected from the group of N-Methylpyrrolidone (NMP), dimethylformamide (DMF), dimethylacetamide (DMAC), hexamethylphosphortriamide (HMPA), dimethyl sulfoxide (DMSO), tetrahydrofuran, propylene carbonate, dimethyl sulfite, N-nitrosodimethylamine, γ-butyrolactone, N:N dimethyl formamide, dimethyl carbonate, methyl formate, butyl formate and mixtures thereof.

25. The process of any of claims 17 - 18, wherein the polar aprotic solvent is dimethyl sulfoxide.

26. The process of any of claims 17 - 18, wherein the slurry catalyst prepared thereof has the formula (M^t)_a(L^u)_b(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h, wherein M is a Primary metal selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

27. A process for preparing a slurry catalyst with improved catalytic activities in the upgrade of heavy oil feedstock, comprising:

providing a slurry catalyst prepared from a solution comprising at least a water-soluble metal precursor salt of a Primary metal selected from Group VIB metals and Group VIII metals and optionally at least a water-soluble metal precursor salt of a Promoter metal selected from Group VIII metals, Group IIB metals, Group IIA metals, Group IYA metals and combinations thereof, and sulfided by a sulfiding agent under sulfiding conditions at a molar ratio of sulfur to metal of at least 1.5:1, wherein the slurry catalyst comprises a plurality of dispersed particles in a hydrocarbon medium having an particle size ranging from 1 to 300 μm ;

providing a hydrogen feed;

treating the slurry catalyst by mixing with the hydrogen feed at a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa) and a temperature from 200°F to 800°F at a rate of from 500 to 15,000 scf hydrogen per bbl of slurry catalyst for a minute to 20 hours, wherein the slurry catalyst treated with hydrogen provides an increase of rate constant k-values in terms of HDS, HDN, and HDMCR of at least 10% compared to a slurry catalyst that is not treated with hydrogen.

28. The process of claim 1, wherein the hydrogen feed is mixed with the slurry catalyst for a sufficient amount of time for the slurry catalyst to have an increase in surface area of at least 10% compare to a slurry catalyst that is not mixed with the hydrogen feed.

29. The process of any of claims 27 - 28, wherein the hydrogen feed is mixed with the slurry catalyst for a sufficient amount of time for the slurry catalyst to have an increase in total pore volume of at least 10% compare to a slurry catalyst that is not mixed with the hydrogen feed.

30. The process of any of claims 27 - 28, wherein the slurry catalyst treated with hydrogen provides an increase of rate constant k-values in terms of HDS, HDN, and HDMCR of at least 15% compared to a slurry catalyst that is not treated with hydrogen.

31. The process of any of claims 27 - 28, wherein the hydrogen feed is mixed with the slurry catalyst in a transfer line prior to being fed to a hydrocracker for the upgrade of heavy oil feedstock.

32. The process of any of claims 27 - 28, wherein the hydrogen feed is mixed with the slurry catalyst in a pre-mixing vessel prior to being fed to a hydrocracker for the upgrade of heavy oil feedstock.

5 33. The process of any of claims 27 - 28, wherein the hydrogen feed is mixed with the slurry catalyst at a temperature of 350°F to 750°F.

34. The process of any of claims 27 - 28, wherein the hydrogen feed is mixed with the slurry catalyst for at least an hour.

10 35. The process of any of claims 27 - 28, wherein the hydrogen feed is mixed with the slurry catalyst for 2 to 5 hours.

36. The process of any of claims 27 - 28, wherein the slurry catalyst composition
15 prepared therefrom has a total pore volume of at least 0.4 cc/g and a polymodal pore distribution with at least 70% of pore sizes in the range of 5 to 2,000 Angstroms in diameter.

37. The process of any of claims 27 - 28, wherein the slurry catalyst composition prepared therefrom has a total surface area of at least 100 m²/g.

20 38. The process of any of claims 27 - 28, wherein the slurry catalyst treated with hydrogen further provides an increase in surface area and total pore volume of at least 10% compared to a slurry catalyst that is not treated with hydrogen.

25 39. The process of claim 38, wherein the slurry catalyst treated with hydrogen further provides an increase in surface area and total pore volume of at least 15% compared to a slurry catalyst that is not treated with hydrogen.

30 40. The process of any of claims 27 - 28, wherein the slurry catalyst has the formula (M^t)_a(L^u)_b(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h, wherein M is a Primary metal selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v,

w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively;
and $ta+ub+vd+we+xf+yg+zh=0$.

41. A process for preparing a slurry catalyst having improved catalytic activities
5 for use in the upgrade of heavy oil feedstock, comprising:

providing at least a solution comprising at least a water-soluble metal precursor salt of
at least a Group VIB metal, the solution having a concentration of less than 10 wt. % of the at
least Group VIB metal in the solution;

sulfiding the at least a solution with a sulfiding agent, forming a sulfided catalyst
10 precursor;

mixing the sulfided catalyst precursor with a hydrocarbon diluent to form a slurry
catalyst;

mixing a hydrogen feed with the slurry catalyst at a pressure from 1435 psig (10
MPa) to 3610 psig (25 MPa) and a temperature from 200°F to 800°F at a rate of from 500 to
15 15,000 scf hydrogen per bbl of slurry catalyst for a minute to 20 hours ,

wherein the slurry catalyst is saturated with hydrogen providing an increase of k-
values in terms of HDS, HDN, and HDMCR of at least 15% compared to a slurry catalyst
that is not saturated with hydrogen.

42. The process of claim 41, further comprising
20 promoting the sulfided catalyst precursor with at least a water-soluble metal precursor
salt of a Promoter metal selected from Group VIII, Group IIB, Group IIA, Group IVA metals
and combinations thereof.

43. The process of any of claims 41 - 42, wherein the solution has a pH of at least
25 4.

44. The process of any of claims 41 - 42, wherein the solution has a concentration
of 5 to 8 wt. % of the Group VIB metal in the solution.

45. The process of any of claims 41 - 42, wherein the slurry catalyst composition
30 prepared therefrom has a total surface area of at least 100 m²/g.

46. The process of any of claims 41 - 42, wherein the slurry catalyst composition prepared therefrom has a total pore volume of at least 0.4 cc/g and a polymodal pore distribution with at least 70% of pore sizes in the range of 5 to 2,000 Angstroms in diameter.

5 47. The process of any of claims 41 - 42, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.5 cc/g.

48. The process of any of claims 41 - 42, wherein the slurry catalyst prepared therefrom has an average particle size ranging from 1 to 300 μm .

10 49. The process of any of claims 41 - 42, wherein the slurry catalyst composition prepared therefrom has an average particle size ranging from 2 to 150 μm .

50. A method for improving the porosimetry of a slurry catalyst, comprising:
15 providing a slurry catalyst having an average particle size ranging from 1 to 300 μm , prepared from a solution comprising at least a water-soluble metal precursor salt of any of a Group VIB metal and a Group VIII metal, and sulfided by a sulfiding agent under sulfiding conditions at a molar ratio of sulfur to metal of at least 1.5:1;

20 treating the slurry catalyst by mixing with the hydrogen feed at a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa) and a temperature from 200°F to 800°F at a rate of from 500 to 15,000 scf hydrogen per bbl of slurry catalyst for a minute to 20 hours,

wherein the slurry catalyst treated with hydrogen provides an increase of rate constant k-values in terms of HDS, HDN, and HDMCR of at least 10% compared to a slurry catalyst that is not treated with hydrogen.

25 51. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing at least a precursor feed comprising at least a Group VIB metal, the precursor feed is a rework material obtained from a process of making hydroprocessing
30 catalysts, wherein the rework material has an average particle size of less than 300 μm ;

mixing the rework material with at least a diluent forming a slurried precursor;

providing at least a sulfiding agent to sulfide the slurried precursor forming the slurry catalyst.

52. The process of claim 51, wherein the rework material is mixed with the diluent in an amount of 5 to 40 wt. % of total weight of the diluent.

53. The process of any of claims 51 - 52, wherein the slurried precursor is mixed with a heavy oil feedstock in a reactor under hydroprocessing conditions at a temperature from 752°F to 1112 °F under a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

54. The process of claim 53, wherein under hydroprocessing conditions the heavy oil feedstock provides the sulfiding agent needed to sulfide the slurried precursor in-situ.

55. The process of any of claims 51 - 52, where the sulfidation of the slurried precursor occurs ex-situ prior to a heavy oil upgrade.

56. The process of claim 55, wherein the sulfiding agent is selected from the group of elemental sulfur, hydrogen sulfide, ammonium sulfide, ammonium polysulfide ($(\text{NH}_4)_2\text{S}_x$), ammonium thiosulfate ($(\text{NH}_4)_2\text{S}_2\text{O}_3$), sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$), thiourea (CSN_2H_4), carbon disulfide, dimethyl disulfide (DMDS), dimethyl sulfide (DMS), tertiarybutyl polysulfide (PSTB) and tertiarynonyl polysulfide (PSTN), and mixtures thereof.

57. The process of any of claims 51 - 52, wherein the diluent is selected from water, VGO, cycle oil, gasoline, distillate, naphtha, light cycle oil, benzene, toluene, xylene, and mixtures thereof.

58. The process of any of claims 51 - 52, wherein the rework material has an average particle size of at least 1 μm .

59. The method of claim 58, wherein the rework material has an average particle size of 2- 150 μm .

60. The process of any of claims 51 - 52, wherein the rework material has an average particle size of less than 100 μm .

61. The process of any of claims 51 - 52, wherein the rework material is obtained from a process of making an unsupported catalyst.

62. The process of any of claims 51 - 52, wherein the rework material is obtained from a process of making a supported catalyst.

63. The process of any of claims 51 - 52, wherein the rework material is ground to
5 an average particle size of less than 300 μm by any of wet grinding and dry grinding.

64. The process of any of claims 51 - 52, wherein the rework material comprises at least one of a metal oxide, a metal hydroxide, a metal sulfide and combinations thereof, affixed onto a carrier comprising one or more of alumina, iron oxide, silica, magnesia, titania,
10 zeolite, silica-aluminate, carbon, phosphorous, and combinations thereof, and ground to an average particle size of less than 300 μm .

65. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

15 providing catalyst fines comprising at least one of an oxide, a hydroxide, a sulfide, and combinations thereof of at least a Primary metal selected from Group IVB metals and Group VIII metals, affixed onto a carrier comprising one or more of alumina, iron oxide, silica, magnesia, titania, zeolite, silica-aluminate, carbon, phosphorous, and combinations thereof, wherein the catalyst fines has an average particle size of less than 300 μm ;
20 mixing the catalyst fines with at least a diluent forming a slurried precursor;
mixing the slurried precursor with at least a heavy oil feedstock for heavy oil upgrade, wherein the heavy oil feedstock releases a sufficient amount of at least a sulfiding agent under in-situ sulfidation conditions to form the slurry catalyst.

25 66. The process of claim 65, wherein the in-situ sulfidation conditions by the heavy oil feedstock occurs at a temperature from 752°F to 1112 °F and a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

67. The process of any of claims 65 - 66, wherein the slurry catalyst prepared
30 from the catalyst fines has a total surface area of at least 100 m^2/g .

68. The process of any of claims 65 - 66, wherein the slurry catalyst prepared from the catalyst fines has a total pore volume of at least 0.3 cc/g and a polymodal pore distribution with at least 70% of pore sizes in the range of 5 to 1,000 Angstroms in diameter.

69. The process of any of claims 65 - 66, wherein the slurry catalyst prepared from the catalyst fines comprises a plurality of dispersed particles with the dispersed particles have an average particle size ranging from 1 to 300 μm .

5 70. The process of any of claims 65 - 66, wherein the slurry catalyst prepared from the catalyst fines has an average particle size ranging from 2 to 150 μm .

71. The process of any of claims 65 - 66, wherein the catalyst fines are obtained from a process of making a supported catalyst.

10 72. The process of any of claims 65 - 66, wherein the catalyst fines are obtained by grinding a supported catalyst to an average particle size of less than 300 μm .

15 73. The process of any of claims 65 - 66, wherein the catalyst fines are mixed with a diluent selected from water, VGO, cycle oil, gasoline, distillate, naphtha, light cycle oil, benzene, diesel oil, heptane, toluene, xylene, and mixtures thereof.

20 74. The process of any of claims 65 - 66, wherein the catalyst fines are provided at a rate of about 10 ppm to about 500 ppm Primary metal per total weight of the heavy oil feedstock.

25 75. The process of any of claims 65 - 66, wherein providing the catalyst fines comprises: a) grinding a support base material to an average particle size of less than 300 μm ; b) impregnating the reduced particle sized support base material with at least a metal precursor; c) drying the impregnated support base material; and d) grinding the impregnated support base material to a particle size of less than 300 μm .

30 76. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing a pressure leach solution obtained from a metal recovery process, the pressure leach solution comprising at least a water-soluble metal precursor salt of a Primary metal, wherein the water-soluble metal precursor salt was previously leached into the pressure leach solution in a leaching step;

mixing the solution with at least a hydrocarbon diluent forming a catalyst precursor;

providing at least a sulfiding agent to sulfide the catalyst precursor forming the slurry catalyst.

77. The process of claim 76, further comprising:

5 subjecting the catalyst precursor to reduction at a temperature above ambient.

78. The process of any of claims 76 - 77, wherein the Primary metal is any of a Group VIB metal, a Group IIB metal, and a Group VIII metal.

10 79. The process of any of claims 76 - 77, wherein the mixing of the pressure leach solution with the at least a hydrocarbon diluent is under high shear mixing to generate an emulsion with droplet sizes ranging from 0.1 to 300 μm .

15 80. The process of any of claims 76 - 77, wherein the catalyst precursor is mixed with the heavy oil feedstock under in-situ sulfiding conditions for the heavy oil feedstock to provide the sulfiding agent needed for the sulfidation forming the slurry catalyst.

20 81. The process of any of claims 76 - 77, where the sulfidation of the catalyst precursor forming the slurry catalyst occurs ex-situ prior to the heavy oil upgrade.

25 82. The process of claim 81, wherein the sulfiding agent is selected from the group of elemental sulfur, hydrogen sulfide, ammonium sulfide, ammonium polysulfide $((\text{NH}_4)_2\text{S}_x)$, ammonium thiosulfate $((\text{NH}_4)_2\text{S}_2\text{O}_3)$, sodium thiosulfate $(\text{Na}_2\text{S}_2\text{O}_3)$, thiourea (CSN_2H_4) , carbon disulfide, dimethyl disulfide (DMDS), dimethyl sulfide (DMS), tertiarybutyl polysulfide (PSTB) and tertiarynonyl polysulfide (PSTN), and mixtures thereof.

30 83. The process of claim 81, wherein the hydrocarbon diluent is selected from gasoline, diesel, vacuum gas oil (VGO), cycle oil (MCO or HCO), jet oil, fuel oil, heavy oil feedstock, and mixtures thereof.

84. The process of any of claims 76 - 77, wherein the pressure leach solution is mixed with the hydrocarbon diluent in an amount of 5 to 50 wt. % of total weight of the hydrocarbon diluent.

85. The process of any of claims 76 - 77, wherein the pressure leach solution is prepared from a pressure leach slurry containing up to 10 wt. % coke and up-to 2 wt% insoluble ammonium metavanadate in the coke by filtering the pressure leach slurry to remove the coke and the ammonium metavanadate.

5

86. The process of any of claims 76 - 77, wherein the pressure leach solution is from a metal recovery process for recovering metals from a spent catalyst.

87. The process of any of claims 76 - 77, wherein the pressure leach solution is from a metal recovery process for recovering metals from mineral ores.

10

88. The process of any of claims 76 - 77, wherein the pressure leach solution is from a metal recovery process for recovering metals from metallurgical wastes.

15

89. The process of any of claims 76 - 77, wherein the pressure leach solution contains a mixture of at least a water-soluble metal precursor salt of a Primary metal and at least a water-soluble metal precursor salt of a Promoter metal.

90. The process of any of claims 76 - 77, wherein the pressure leach solution contains a mixture of ammonium heptamolybdate and nickel sulfate.

20

91. The process of any of claims 76 - 77, wherein the pressure leach solution contains at least 50 to 90 g/L (grams per liter) molybdenum and 3 to 10 g/L nickel.

25

92. The process of any of claims 76 - 77, wherein the slurry catalyst prepared therefrom has a total surface area of at least 100 m²/g, a total pore volume of at least 0.4 cc/g and a polymodal pore distribution with at least 90% of pore sizes in the range of 5 to 1,000 Angstroms in diameter.

30

93. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing a pressure leach solution containing a mixture of at least a water-soluble metal precursor salt of a Primary metal and at least a water-soluble metal precursor salt of a

Promoter metal obtained from a metal recovery process and wherein the metal precursor salts were previously leached into the pressure leach solution in a leaching step;

mixing the at least a metal precursor solution with at least a hydrocarbon diluent forming a catalyst precursor;

- 5 mixing the at least a catalyst precursor with at least a heavy oil feedstock under in-situ sulfiding conditions for the heavy oil feedstock to provide at least a sulfiding agent to sulfide the catalyst precursor forming a slurry catalyst.

94. The process of claim 93, wherein the pressure leach solution is from a metal
10 recovery process for recovering metals from a spent catalyst.

95. The process of any of claims 93 - 94, wherein the at least a metal precursor was mixed with the heavy oil feedstock at a temperature from 752°F to 1112 °F under a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa) for in-situ sulfiding to take place.
15

96. The process of any of claims 93 - 94, wherein the hydrocarbon diluent is selected from gasoline, diesel, vacuum gas oil (VGO), cycle oil (MCO or HCO), jet oil, fuel oil, heavy oil feedstock, and mixtures thereof.

20 97. The process of any of claims 93 - 94, wherein the pressure leach solution contains a mixture of ammonium heptamolybdate and nickel sulfate.

98. The process of any of claims 93 - 94, wherein the slurry catalyst prepared therefrom has an average particle size ranging from 1 to 300 μm .

25 99. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing a pressure leach solution obtained from a metal recovery process, the pressure leach solution comprising at least a water-soluble metal precursor salt of a Primary
30 metal, wherein the water-soluble metal precursor salt was previously leached into the pressure leach solution in a leaching step;

providing at least a sulfiding agent to sulfide the pressure leach solution forming a catalyst precursor;

mixing the catalyst precursor with at least a hydrocarbon diluent under reducing conditions forming the slurry catalyst.

100. The process of claim 99, wherein the slurry catalyst is of the formula
 5 $(M^t)_a(L^u)_b(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h$, wherein the Primary metal M is selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z,
 10 each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

101. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

15 providing a metal precursor solution comprising a mixture of at least two different water-soluble metal salts in a water solvent of at least two different metals selected from Group VIB, Group VIII, Group IVB, Group IIB metals and mixtures thereof;

mixing the metal precursor solution with a hydrocarbon diluent under high shear mixing to generate an emulsion with droplet sizes ranging from 0.1 to 300 μm ;

20 sulfiding the emulsion with at least a sulfiding agent to form the slurry catalyst having an average particle size ranging from 1 to 300 μm .

102. The process of claim 101, further comprising:

25 subjecting the emulsion to reduction in the presence of a reducing agent at a temperature above ambient.

103. The process of any of claims 101 - 102, wherein the emulsion is mixed with the heavy oil feedstock in a reactor under in-situ sulfiding condition for the heavy oil feedstock to provide the sulfiding agent needed for to sulfide the emulsion forming the slurry
 30 catalyst.

104. The process of claim 103, wherein the in-situ sulfiding condition is at a temperature from 752°F to 1112 °F and a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

105. The process of any of claims 101 - 102, where the sulfidation of the emulsion forming the slurry catalyst occurs ex-situ prior to the heavy oil upgrade.

106. The process of claim 105, wherein the sulfiding agent is selected from the group of elemental sulfur, hydrogen sulfide, ammonium sulfide, ammonium polysulfide $((\text{NH}_4)_2\text{S}_x)$, ammonium thiosulfate $((\text{NH}_4)_2\text{S}_2\text{O}_3)$, sodium thiosulfate $(\text{Na}_2\text{S}_2\text{O}_3)$, thiourea (CSN_2H_4) , carbon disulfide, dimethyl disulfide (DMDS), dimethyl sulfide (DMS), tertiarybutyl polysulfide (PSTB) and tertiarynonyl polysulfide (PSTN), and mixtures thereof.

107. The process of claim 105, wherein the hydrocarbon diluent is selected from gasoline, diesel, vacuum gas oil (VGO), cycle oil (MCO or HCO), jet oil, fuel oil, heavy oil feedstock, and mixtures thereof.

108. The process of claim 105, further comprising
subjecting the slurry catalyst after ex-situ sulfidation to reduction at a temperature above ambient.

109. The process of any of claims 101 - 102, wherein the emulsion precursor comprises droplets having a size of less than 100 μm .

110. The process of any of claims 101 - 102, wherein the emulsion droplets contain metal precursor solution in a hydrocarbon diluent.

111. The process of any of claims 101 - 102, wherein the emulsion droplets contain hydrocarbon diluent in a metal precursor solution.

112. The process of any of claims 101 - 102, wherein the slurry prepared therefrom has a general formula $(\text{M}^t)_a(\text{L}^u)_b(\text{S}^v)_d(\text{C}^w)_e(\text{H}^x)_f(\text{O}^y)_g(\text{N}^z)_h$, wherein M is a Primary metal selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

113. The process of any of claims 101 - 102, wherein the slurry catalyst prepared therefrom has a total surface area of at least 100 m²/g.

114. The process of any of claims 101 - 102, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.4 cc/g and a polymodal pore distribution with at least 70% of pore sizes in the range of 5 to 1,000 Angstroms in diameter.

115. The process of any of claims 101 - 102, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.5 cc/g.

116. The process of any of claims 101 - 102, wherein the slurry catalyst prepared therefrom has an average particle size ranging from 1 to 300 μm.

117. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing a metal precursor solution comprising at least a water-soluble Group VIB metal salt and a water-soluble Group VIII metal salt in a water solvent;

mixing the at least a metal precursor solution with a hydrocarbon diluent under high shear mixing to generate an emulsion precursor comprising droplets having a size of 0.1 to 300 μm, the hydrocarbon diluent selected from gasoline, diesel, vacuum gas oil (VGO), cycle oil (MCO or HCO), jet oil, fuel oil, heavy oil feedstock, and mixtures thereof;

mixing the emulsion with a heavy oil feedstock under in-situ sulfiding condition for the heavy oil feedstock to provide the sulfiding agent needed for to sulfide the emulsion forming a slurry catalyst having an average particle size ranging from 1 to 300 μm.

118. The process of claim 117, wherein the mixing of the emulsion precursor with the heavy oil feedstock is at a temperature from 752°F to 1112°F under a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

119. The process of any of claims 117 - 118, wherein the slurry catalyst prepared therefrom has a total surface area of at least 100 m²/g.

120. The process of any of claims 117 - 118, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.4 cc/g and a polymodal pore distribution with at least 70% of pore sizes in the range of 5 to 1,000 Angstroms in diameter.

121. The process of any of claims 117 - 118, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.5 cc/g.

122. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing a metal precursor solution comprising at least a water-soluble Group VIB metal salt and a water-soluble Group VIII metal salt in a water solvent;

sulfiding the metal precursor solution with at least a sulfiding agent forming a water-based catalyst precursor;

mixing the water-based catalyst precursor with a hydrocarbon diluent from gasoline, diesel, vacuum gas oil, cycle oil, jet oil, fuel oil, heavy oil feedstock, and

subjecting the mixture of water-based catalyst precursor and hydrocarbon diluent to reduction in the presence of a reducing agent at a temperature above ambient forming a slurry catalyst of the formula $(M^t)_a(L^u)_b(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h$, wherein M is a Primary metal selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

123. The process of claim 122, wherein the mixing of the water-based catalyst precursor with a hydrocarbon diluent is in the presence of a reducing agent and under reduction conditions.

124. The process of any of claims 122 - 123, wherein the mixing the water-based catalyst precursor with a hydrocarbon diluent the hydrocarbon diluent is at a high shear rate for at least a portion of the water-based catalyst precursor to be in emulsion having droplets with particle sizes ranging from 1 to 300 μm .

125. A slurry catalyst for use in hydroprocessing a heavy oil feedstock, wherein:
the slurry catalyst comprises a plurality of dispersed particles in a hydrocarbon
medium, wherein the dispersed particles have an average particle size ranging from 1 to 300
μm,

5 the slurry catalyst has a polymodal pore distribution with at least 80% of pore sizes in
the range of 5 to 2,000 Angstroms in diameter, and

the slurry catalyst is prepared from sulfiding and dispersing a metal precursor solution
in a hydrocarbon diluent, the metal precursor solution comprising at least a water-soluble salt
of a Primary metal selected from Group VIB, Group IIB metals and Group VIII metals, the
10 metal precursor solution having a pH of at least 4 and a concentration of less than 10 wt. % of
the Primary metal in solution.

126. The slurry catalyst of claim 125, wherein the slurry catalyst has a BET surface
area ranging from 200 to 800 m²/g.

15 127. The slurry catalyst of any claims 125 - 126, wherein the Primary metal is
molybdenum and wherein the water-soluble metal salt is selected from the group of
molybdates, alkali metal heptamolybdates, alkali metal orthomolybdates, alkali metal
isomolybdates, phosphomolybdic acid, molybdenum oxide, molybdenum carbide,
20 molybdenum nitride, aluminum molybdate, molybdic acid, and mixtures thereof.

128. The slurry catalyst of any claims 125 - 126, wherein the metal precursor
solution further comprises at least a water-soluble salt of a Promoter metal selected from any
of Group IVB metals, Group VIII metals, and Group IIB metals, wherein the Promoter metal
25 is different from the Primary metal, and the Promoter metal is present in a weight ratio of 1-
50 wt. %. Promoter metal to Primary metal.

30 129. The slurry catalyst of any claims 125 - 126, wherein the Promoter metal is
nickel and wherein the water-soluble metal salt of the Promoter metal is selected from the
group of nickel acetate, nickel carbonate, nickel chloride, nickel sulfate, nickel nitrate, nickel
acetylacetonate, nickel citrate, nickel oxalate, and mixtures thereof.

130. The slurry catalyst of any claims 125 - 126, wherein at least 70% of the pore
sizes are in the range of 5 to 1000 Angstroms in diameter.

131. The slurry catalyst of any claims 125 - 126, wherein at least 50% of the pore sizes are in the range of 5 to 5000 Angstroms in diameter.

132. The slurry catalyst of any claims 125 - 126, wherein at least 30% of the pore sizes are at least 100 Angstroms in diameter.

133. The slurry catalyst of any claims 125 - 126, wherein the slurry catalyst has a total pore volume of at least 0.5 cc/g.

134. The slurry catalyst of claim 6, wherein the slurry catalyst has a total pore volume of at least 0.8 cc/g.

135. The slurry catalyst of any claims 125 - 126, wherein the catalyst has an average particle size ranging from 2 to 100 μm .

136. The slurry catalyst of any claims 125 - 126, the metal precursor solution having a pH of at least 4 and a concentration of at least 0.1 wt. % of the Primary metal in solution.

137. The slurry catalyst of any claims 125 - 126, the metal precursor solution having a pH of at least 5.

138. The slurry catalyst of any claims 125 - 126, wherein the slurry catalyst has a general formula $(M^t)_a(L^u)_b(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h$, wherein M is a Primary metal selected from group VIB metals, Group VIII metals, and Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

139. The slurry catalyst of claim 138, wherein M is selected from molybdenum, tungsten, and mixtures thereof and L is selected from nickel, cobalt, and mixture thereof.

140. The slurry catalyst of claim 138, wherein the Group VIB metal is molybdenum and the slurry catalyst is essentially free of Promoter metals.

141. The slurry catalyst of claim 16, wherein $b=0$, and the Primary metal M is
5 nickel.

142. The slurry catalyst of any claims 125 - 126, wherein the slurry catalyst has a
1000°F+ conversion rate of at least 50% for the upgrade of a heavy oil feedstock having an
API gravity of at most 15, when the slurry catalyst is applied at a rate of less than 2 wt. %
10 active Group VIB metal relative to the total weight of the heavy oil feedstock,

143. The slurry catalyst of claim 138, wherein the slurry catalyst has an X-ray
powder diffraction pattern with a first broad diffraction peak at Bragg angle of 8 to 18° and a
second broad diffraction peak at Bragg angle of 32 to 40° (from 0 to 70° 2θ scale).
15

144. The slurry catalyst of any claims 125 - 126, wherein the slurry catalyst
comprises a plurality of dispersed particles in a hydrocarbon medium selected from gasoline,
diesel, vacuum gas oil, cycle oil, jet oil, fuel oil, heavy oil feedstock, and mixtures thereof.

145. A slurry catalyst for use in hydroprocessing a heavy oil feedstock, wherein:
the slurry catalyst comprises a plurality of dispersed particles in a hydrocarbon
medium, wherein the dispersed particles have an average particle size ranging from 1 to 300
μm,
20

the slurry catalyst has a BET total surface area of at least 100 m²/g, and

25 the slurry catalyst is prepared from sulfiding and dispersing a metal precursor solution
in a hydrocarbon diluent, the metal precursor solution comprising at least a water-soluble salt
of a Primary metal selected from Group VIB metals, Group IIB metals, and Group VIII
metals, the metal precursor solution having a pH of at least 4 and a concentration of less than
10 wt. % of Primary metal in solution.

30 146. The slurry catalyst of claim 145, wherein at least 70% of the pore sizes are in
the range of 5 to 1000 Angstroms in diameter.

147. The slurry catalyst of any of claims 145 - 146, wherein the slurry catalyst has a BET surface area ranging from 200 to 800 m²/g.

148. The slurry catalyst of any of claims 145 - 146, wherein at least 50% of the pore sizes are in the range of 5 to 5000 Angstroms in diameter.

149. The slurry catalyst of claim 148, wherein at least 30% of the pore sizes are at least 100 Angstroms in diameter.

150. The slurry catalyst of any of claims 145 - 146, wherein the slurry catalyst has a total pore volume of at least 0.5 cc/g.

151. The slurry catalyst of any of claims 145 - 146, wherein the slurry catalyst has a total pore volume of at least 0.8 cc/g.

152. The slurry catalyst of any of claims 145 - 146, wherein the catalyst has an average particle size ranging from 2 to 100 μm.

153. The slurry catalyst of any of claims 145 - 146, wherein the metal precursor solution further comprises at least a water-soluble salt of a Promoter metal selected from any of Group IVB metals, Group VIII metals, and Group IIB metals, wherein the Promoter metal is different from the Primary metal, and the Promoter metal is present in a weight ratio of 1-50 wt. %. Promoter metal to Primary metal.

154. The slurry catalyst of any of claims 145 - 146, wherein the metal precursor solution has a pH of at least 4 and a concentration of at least 0.1 wt. % of Primary metal in solution.

155. The slurry catalyst of claim 154, wherein the metal precursor solution has a pH of at least 4 and a concentration of 5 - 10 wt. % Primary metal in solution.

156. The slurry catalyst of any of claims 145 - 146, wherein the Primary metal precursor is a water-soluble Group VIB metal salt.

157. The slurry catalyst of any of claims 145 - 146, wherein the slurry catalyst comprises a plurality of dispersed particles in a hydrocarbon medium selected from gasoline, diesel, vacuum gas oil (VGO), cycle oil (MCO or HCO), jet oil, fuel oil, heavy oil feedstock, and mixtures thereof.

158. The slurry catalyst of any of claims 145 - 146, wherein the catalyst is prepared from a metal precursor consisting essentially of a least a Group VIB metal compound.

159. The slurry catalyst of any of claims 145 - 146, wherein the slurry catalyst has a general formula $(M^t)_a(L^u)_b(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h$, wherein the Primary metal M is selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

160. A slurry catalyst for use in hydroprocessing a heavy oil feedstock, wherein: the slurry catalyst is prepared from at least a metal precursor solution comprising at least a water-soluble salt of a Primary metal selected from Group VIB metals and a water-soluble salt of a Promoter metal selected from Group VIII, Group IIB, Group IIA, Group IVA metals and combinations thereof; the slurry catalyst is prepared from sulfiding and dispersing the metal precursor solution in a hydrocarbon diluent, the metal precursor solution having a pH of at least 4 and a concentration of less than 10 wt. % of the Primary metal in solution; and wherein

the slurry catalyst has an average particle size of 1 – 300 μm and a BET total surface area of at least 100 m^2/g .

161. The slurry catalyst composition of claim 160, wherein the slurry catalyst is characterized as having a 1000°F+ conversion rate of at least 50% for the upgrade of a heavy oil feedstock having an API gravity of at most 15, when applied at a rate of less than 1 wt. % Primary metal relative to the total weight of the heavy oil feedstock,

162. The slurry catalyst of any of claims 160 - 161, wherein the metal precursor solution has a concentration of 5 – 10 wt. % Primary metal in solution.

163. The slurry catalyst of any of claims 160 - 161, wherein the Primary metal is molybdenum and wherein the water-soluble metal precursor salt is selected from the group of molybdates, alkali metal heptamolybdates, alkali metal orthomolybdates, alkali metal isomolybdates, phosphomolybdic acid, molybdenum oxide, molybdenum carbide, molybdenum nitride, aluminum molybdate, molybdic acid, and mixtures thereof.

164. The slurry catalyst of any of claims 160 - 161, wherein the Promoter metal is nickel and wherein the water-soluble metal salt of the Promoter metal is selected from the group of nickel acetate, nickel carbonate, nickel chloride, nickel sulfate, nickel nitrate, nickel acetylacetonate, nickel citrate, nickel oxalate, and mixtures thereof.

165. A process for preparing a slurry catalyst for use in the upgrade of heavy oil feedstock, comprising:

providing a metal precursor solution comprising at least a water soluble salt of a Primary metal selected from any of a Group VIB metal and a Group VIII metal in a water diluent, the metal precursor solution having a pH of at least 4 and a concentration of less than 10 wt. % of the Primary metal in solution;

sulfiding the metal precursor solution with a sulfiding agent, forming a sulfided catalyst precursor; and

mixing the sulfided catalyst precursor with a hydrocarbon diluent to form the slurry catalyst wherein a slurry catalyst prepared therefrom has an average particle size ranging from 1 to 300 μm , a BET total surface area of at least 100 m^2/g , a polymodal pore distribution with at least 80% of pore sizes in the range of 5 to 2,000 Angstroms in diameter, and a total pore volume of at least 0.5 cc/g.

166. The process of claim 165, wherein the the sulfided catalyst precursor with a hydrocarbon diluent is in the presence of a reducing agent and under reducing conditions.

167. The process of any of claims 165 - 166, wherein the metal precursor solution further comprises at least a water-soluble salt of a Promoter metal selected from any of Group IVB metals, Group VIII metals, and Group IIB metals, wherein the Promoter metal is

different from the Primary metal, and the Promoter metal is present in a weight ratio of 1-50 wt. %. Promoter metal to Primary metal.

168. The process of any of claims 165 - 166, wherein the slurry catalyst prepared therefrom has a BET surface area from 200 to 800 m²/g.

169. The process of any of claims 165 - 166, wherein the slurry catalyst prepared therefrom has at least 70% of pore sizes of 5 to 1000 Angstroms in diameter.

170. The process of any of claims 165 - 166, wherein the slurry catalyst prepared therefrom has at least 50% of the pore sizes of 5 to 5000 Angstroms in diameter.

171. The process of any of claims 165 - 166, wherein the slurry catalyst prepared therefrom has at least 30% of the pore sizes of at least 100 Angstroms in diameter.

172. The process of any of claims 165 - 166, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.5 cc/g.

173. The process of any of claims 165 - 166, wherein the slurry catalyst has a total pore volume of at least 0.8 cc/g.

174. The process of any of claims 165 - 166, wherein the slurry catalyst prepared therefrom has an average particle size from 2 to 100 μ m.

175. The process of any of claims 165 - 166, wherein the metal precursor solution has a concentration of 5 - 10 wt. % of the Primary metal in solution.

176. The process of any of claims 165 - 166, wherein the metal precursor solution has a concentration of at least 0.1 wt. % of the Primary metal in solution.

177. The process of any of claims 165 - 166, wherein the Primary metal is molybdenum and wherein the water-soluble metal precursor salt is selected from the group of molybdates, alkali metal heptamolybdates, alkali metal orthomolybdates, alkali metal

isomolybdates, phosphomolybdic acid, molybdenum oxide, molybdenum carbide, molybdenum nitride, aluminum molybdate, molybdic acid, and mixtures thereof.

178. The process of claim 167, wherein the Promoter metal is nickel and wherein
5 the water-soluble metal salt of the Promoter metal is selected from the group of nickel acetate, nickel carbonate, nickel chloride, nickel sulfate, nickel nitrate, nickel acetylacetonate, nickel citrate, nickel oxalate, and mixtures thereof.

179. The process of any of claims 165 - 166, further comprising:
10 mixing at least a metal precursor solution comprising at least a water-soluble salt of a Promoter metal selected from any of Group IVB metals, Group VIII metals, and Group IIB metals into the sulfided catalyst precursor, prior to mixing the sulfided catalyst precursor with the hydrocarbon diluent.

180. The process of any of claims 165 - 166, further comprising:
15 providing a metal precursor solution comprising at least a water-soluble salt of a Promoter metal selected from any of Group IVB metals, Group VIII metals, and Group IIB metals;
sulfiding the at least a metal precursor solution comprising at least a water-soluble salt
20 of a Promoter metal with a sulfiding agent, forming a sulfided Promoter metal precursor; and
mixing the sulfided Promoter metal precursor into the sulfided catalyst precursor prior to mixing the sulfided catalyst precursor with the hydrocarbon diluent.

181. The process of any of claims 165 - 166, wherein the hydrocarbon diluent
25 comprises a heavy oil feedstock and wherein the metal precursor solution is mixed with the heavy oil feedstock under in-situ sulfiding condition for the heavy oil feedstock to provide the sulfiding agent needed to form the slurry catalyst.

182. The process of claim 181, wherein the in-situ sulfiding condition is at a
30 temperature from 752°F to 1112 °F and a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

183. The process of any of claims 165 - 166, where the sulfidation of the metal precursor solution occurs ex-situ prior to the heavy oil upgrade.

184. The process of any of claims 165 - 166, wherein the sulfiding agent is selected from the group of elemental sulfur, hydrogen sulfide, ammonium sulfide, ammonium polysulfide $((\text{NH}_4)_2\text{S}_x)$, ammonium thiosulfate $((\text{NH}_4)_2\text{S}_2\text{O}_3)$, sodium thiosulfate $(\text{Na}_2\text{S}_2\text{O}_3)$, thiourea (CSN_2H_4) , carbon disulfide, dimethyl disulfide (DMDS), dimethyl sulfide (DMS),
 5 tertiarybutyl polysulfide (PSTB) and tertiarynonyl polysulfide (PSTN), and mixtures thereof.

185. The process of any of claims 165 - 166, wherein the hydrocarbon diluent is selected from gasoline, diesel, vacuum gas oil (VGO), cycle oil (MCO or HCO), jet oil, fuel oil, heavy oil feedstock, and mixtures thereof.

186. The process of any of claims 165 - 166, wherein the slurry catalyst prepared therefrom has a general formula $(\text{M}^t)_a(\text{L}^u)_b(\text{S}^v)_c(\text{C}^w)_e(\text{H}^x)_f(\text{O}^y)_g(\text{N}^z)_h$, wherein M is a Primary metal selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group
 15 VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

187. A process for preparing a slurry catalyst composition, comprising:
 sulfiding a water-soluble metal precursor salt of a Group VIB metal in a water diluent with at least a sulfiding agent forming a sulfided Group VIB metal compound;
 combining and reacting the sulfided Group VIB metal compound with a water-soluble metal precursor salt of a Promoter metal selected from Group VIII, Group IIB, Group IIA,
 25 and Group IVA metals and combinations thereof in a water diluent to form a catalyst precursor;
 mixing the catalyst precursor with a hydrocarbon diluent to form a slurry catalyst composition having an average particle size ranging from 1 to 300 μm , a BET total surface area of at least 100 m^2/g , a polymodal pore distribution with at least 80% of pore sizes in the
 30 range of 5 to 2,000 Angstroms in diameter, and a total pore volume of at least 0.5 cc/g;
 wherein at least one of the water-soluble metal precursor salt of a Group VIB metal in a water diluent and the water-soluble metal precursor salt of a Promoter metal in a water diluent has a pH of at least 4 and a concentration of less than 10 wt. % of metal in solution.

188. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing at least a metal precursor in solution comprising at least two different metal cations in its molecular structure, with at least one of the metal cations is a Group VIB metal cation;

sulfiding the metal precursor with a sulfiding agent forming a catalyst precursor; and mixing the catalyst precursor with a hydrocarbon diluent to form a slurry catalyst having an average particle size of 1 – 300 μm .

189. The process of claim 1, wherein the mixing of the catalyst precursor with the hydrocarbon diluent is in the presence of a reducing agent and under reducing conditions.

190. The process of any of claims 188 - 189, wherein the mixing of the catalyst precursor with the hydrocarbon diluent is under high shear mixing forming an emulsion having droplets with particle sizes ranging from 1 to 300 μm .

191. The process of any of claims 188 - 189, wherein providing the at least a metal precursor comprising at least two different metal cations comprises combining and reacting at least a Group VIB metal compound with at least a Promoter metal compound selected from Group VIII, Group IIB, Group IIA, Group IVA metals and combinations thereof.

192. The process of claim 191, wherein the at least one Group VIB metal compound is a water-soluble Group VIB metal salt in solution and the Promoter metal compound is a water-soluble Group VIII metal salt in solution.

193. The process of claim 192, wherein the water-soluble Group VIB metal salt in solution is selected from the group of ammonium dimolybdate, ammonium heptamolybdate, ammonium octamolybdate, potassium molybdate, potassium chromium sulfate, ammonium para-molybdate and mixtures thereof.

194. The process of claim 192, wherein the water-soluble Group VIII metal salt in solution is selected from the group of nickel sulfate, nickel ammonium sulfate, iron sulfate, and mixtures thereof.

195. The process of claim 191, wherein the Group VIB metal compound is an oil soluble molybdenum salt and the Promoter metal compound is an oil soluble Group VIII metal salt.

5 196. The process of claim 191, wherein the at least one Group VIB metal compound is ammonium dimolybdate and the Promoter metal compound is nickel sulfate.

197. The process of any of claims 188 - 189, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.4 cc/g.

10 198. The process of any of claims 188 - 189, wherein the slurry catalyst prepared therefrom has a polymodal pore distribution with at least 80% of pore sizes in the range of 5 to 2,000 Angstroms in diameter.

15 199. The process of any of claims 188 - 189, wherein the slurry catalyst prepared therefrom has polymodal pore distribution with at least at least 80% of the pore sizes are in the range of 5 to 1000 Angstroms in diameter.

20 200. The process of any of claims 188 - 189, wherein the slurry catalyst prepared therefrom has a total surface area of at least 100 m²/g.

201. The process of any of claims 188 - 189, wherein the slurry catalyst prepared therefrom has an average particle size ranging from 2 to 100 μ m.

25 202. The process of claim 192, wherein the water-soluble Group VIB metal salt in solution has a concentration of 5 - 8 wt. % of Group VIB metal.

30 203. The process of claim 202, wherein the water-soluble Group VIB metal salt in solution has a pH of at least 4.

204. The process of claim 192, wherein the water-soluble Group VIII metal salt in solution has a pH of at least 4.

205. The process of claim 204, wherein the water-soluble Group VIII metal salt in solution has a concentration of 5 – 8 wt. % of Group VIB metal.

206. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing at least a metal precursor in solution comprising at least two different metal cations in its molecular structure, with at least one of the metal cations is a Group VIB metal cation and at least one of the metal cations is a Promoter metal cation selected from Group VIII, Group IIB, Group IIA, Group IVA metals and combinations thereof;

sulfiding the metal precursor with a sulfiding agent in solution forming a catalyst precursor; and

mixing the catalyst precursor with a hydrocarbon diluent to form the slurry catalyst.

207. The process of claim 206, wherein at least one of the Group VIB water-soluble salt in a water diluent and the Group VIII water-soluble salt in a water diluent has a pH of at least 4.

208. The process of any claims 206 - 207, wherein at least one of the Group VIB water-soluble salt in a water diluent and the Group VIII water-soluble salt in a water diluent has a metal concentration of 4 to 8 wt. %.

209. The process of any claims 206 - 207, wherein providing the at least a metal precursor comprising at least two different metal cations comprises combining and reacting: a Group VIB water-soluble salt in a water diluent, the Group VIB water soluble salt is selected from the group of ammonium dimolybdate, ammonium heptamolybdate, ammonium octamolybdate, potassium molybdate, potassium chromium sulfate, ammonium paramolybdate and mixtures thereof; and a Group VIII water-soluble salt in a water diluent, the Group VIII water soluble salt is selected from the group of nickel sulfate, nickel ammonium sulfate, iron sulfate, and mixtures thereof.

210. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing at least a metal precursor of a Primary metal, the Primary metal is selected from a Group VIII metal, a Group IVB metal, and a Group IIB metal;

sulfiding the Primary metal precursor with a sulfiding agent forming a catalyst precursor; and

mixing the catalyst precursor with a hydrocarbon diluent to form a slurry catalyst having a particle size ranging from 1 to 300 μm ; and a general formula of

5 $(M^t)_a(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h$, wherein M is any of a Group VIII metal, a Group IVB metal, and a Group IIB metal; $0.5a \leq d \leq 4a$; $0 \leq e \leq 11a$; $0 \leq f \leq 18a$; $0 \leq g \leq 2a$; $0 \leq h \leq 3a$; t, v, w, x, y, z, each representing total charge for each of: M, S, C, H, O, and N; and $ta+vd+we+xf+yg+zh=0$.

10 211. The process of claim 210, wherein the mixing of the catalyst precursor with the hydrocarbon diluent is in the presence of a reducing agent and under reducing conditions.

15 212. The process of any claims 210 - 211, wherein the mixing of the catalyst precursor with the hydrocarbon diluent is under high shear mixing forming an emulsion having droplets with particle sizes ranging from 1 to 300 μm .

20 213. The process of any claims 210 - 211, wherein the Primary metal precursor is a water soluble metal salt selected from the group of acetates, carbonates, chlorides, nitrates, sulfates, citrates, oxalates, and mixtures thereof.

25 214. The process of any claims 210 - 211, wherein the hydrocarbon diluent is selected from gasoline, diesel, vacuum gas oil (VGO), cycle oil (MCO or HCO), jet oil, fuel oil, heavy oil feedstock, and mixtures thereof.

30 215. The process of any claims 210 - 211, wherein the sulfiding agent is selected from the group of elemental sulfur, hydrogen sulfide, ammonium sulfide, ammonium polysulfide $((\text{NH}_4)_2\text{S}_x)$, ammonium thiosulfate $((\text{NH}_4)_2\text{S}_2\text{O}_3)$, sodium thiosulfate $(\text{Na}_2\text{S}_2\text{O}_3)$, thiourea (CSN_2H_4) , carbon disulfide, dimethyl disulfide (DMDS), dimethyl sulfide (DMS), tertiarybutyl polysulfide (PSTB) and tertiarynonyl polysulfide (PSTN), and mixtures thereof.

216. The process of any claims 210 - 211, wherein the Primary metal is nickel and the Primary metal precursor is selected from the group of nickel naphthenate, nickel acetate, nickel oxalate, nickel citrate, nickel octotate, nickel dithiocarbamate, and mixtures thereof.

217. The process of any claims 210 - 211, wherein the sulfidation of the Primary metal precursor and the mixing with a hydrocarbon diluent occurs concurrently.

218. The process of any claims 210 - 211, wherein the Primary metal precursor is mixed with the heavy oil feedstock under in-situ sulfiding conditions for the heavy oil feedstock to provide the sulfiding agent needed for the sulfidation forming the slurry catalyst.

219. The process of claim 218, wherein the mixing of the Primary metal precursor with the heavy oil feedstock is at a temperature from 752°F to 1112°F under a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

220. The process of any claims 210 - 211, wherein the concentration of the Primary metal in the Primary metal precursor solution is less than 10 wt. %.

221. The process of any claims 210 - 211, wherein the Primary metal precursor solution has a pH of at least 4.

222. The process of any claims 210 - 211, wherein the concentration of the Primary metal in the Primary metal precursor solution is between 4 - 8 wt. %.

223. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing at least a water-soluble nickel salt in solution, wherein the nickel salt is selected from the group of nickel nitrate, nickel sulfate, nickel acetate, nickel chloride, and mixtures thereof;

providing at least a hydrocarbon diluent is selected from gasoline, diesel, vacuum gas oil, cycle oil, jet oil, diesel, naphtha, fuel oil, heavy oil feedstock, and mixtures thereof;

mixing the water-soluble nickel salt in solution with the hydrocarbon diluent under high shear mixing condition forming an emulsion comprising droplets having a size of 0.1 to 300 μm ;

mixing the emulsion with a heavy oil feedstock under in-situ sulfiding condition to form the slurry catalyst.

224. The process of claim 223, wherein the mixing under high shear mixing condition forms an emulsion comprising droplets having a size of less than 50 μm .

225. The process of any of claims 223 - 224, wherein the mixing of the emulsion with the heavy oil feedstock is at a temperature from 752°F to 1112°F under a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

226. The process of any claims 223 - 224, wherein the nickel salt solution has a pH of at least 4.

227. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing at least an organic nickel complex;

mixing the organic nickel complex with the hydrocarbon diluent under high shear mixing condition forming an emulsion comprising droplets having a size of 0.1 to 300 μm ;

sulfiding the emulsion with at least a sulfiding agent to form a slurry catalyst having a particle size ranging from 1 to 300 μm ; and a general formula of

$(M^t)_a(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h$, wherein M is any of a non-noble Group VIII metal, a Group IVB metal, and a Group IIB metal; $0.5a \leq d \leq 4a$; $0 \leq e \leq 11a$; $0 \leq f \leq 18a$; $0 \leq g \leq 2a$; $0 \leq h \leq 3a$; t, v, w, x, y, z, each representing total charge for each of: M, S, C, H, O, and N; and $ta+vd+we+xf+yg+zh=0$.

228. The process of claim 227, wherein the hydrocarbon diluent comprises a heavy oil feedstock and wherein the organic nickel complex is mixed with the heavy oil feedstock under in-situ sulfiding conditions for the heavy oil feedstock to provide the sulfiding agent needed for the sulfidation forming the slurry catalyst.

229. The process of claim 227, wherein the mixing of the nickel salt with the heavy oil feedstock is at a temperature from 752°F to 1112°F under a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

230. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing a metal precursor solution comprising at least a water-soluble molybdenum compound and a water-soluble metal zinc compound in water;

mixing the metal precursor solution with a hydrocarbon diluent under sufficiently high shear mixing to generate an emulsion with droplet sizes ranging from 0.1 to 300 μm ;

5 sulfiding the emulsion with at least a sulfiding agent to form a slurry catalyst having a particle size ranging from 1 to 300 μm ;

wherein the zinc compound is present in the slurry catalyst in a sufficient amount for a zinc to molybdenum weight ratio ranging from 1:10 to 10:1.

10 231. The process of claim 230, further comprising:

subjecting the emulsion to reduction at a temperature above ambient before or after the sulfiding step.

15 232. The process of claims 230 - 231, wherein the emulsion is mixed with the heavy oil feedstock in a reactor under in-situ sulfiding condition for the heavy oil feedstock to provide the sulfiding agent needed for to sulfide the emulsion forming the slurry catalyst.

20 233. The process of claim 3, wherein the in-situ sulfiding condition is at a temperature from 752°F to 1112 °F and a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa).

234. The process of claims 230 - 231, where the sulfidation of the emulsion forming the slurry catalyst occurs ex-situ prior to the heavy oil upgrade.

25 235. The process of claim 234, wherein the sulfiding agent is selected from the group of elemental sulfur, hydrogen sulfide, ammonium sulfide, ammonium polysulfide ($(\text{NH}_4)_2\text{S}_x$), ammonium thiosulfate $(\text{NH}_4)_2\text{S}_2\text{O}_3$, sodium thiosulfate $\text{Na}_2\text{S}_2\text{O}_3$, thiourea CSN_2H_4 , carbon disulfide, dimethyl disulfide (DMDS), dimethyl sulfide (DMS), tertiarybutyl polysulfide (PSTB) and tertiarynonyl polysulfide (PSTN), and mixtures thereof.

30 236. The process of claims 230 - 231, wherein the hydrocarbon diluent is selected from gasoline, diesel, vacuum gas oil, cycle oil, jet oil, fuel oil, heavy oil feedstock, and mixtures thereof.

237. The process of claim 5, wherein a sufficient amount of sulfiding agent is provided a molar ratio of sulfur to molybdenum of at least 1.5 to 1 to sulfide the emulsion to form the slurry catalyst.

5 238. The process of claims 230 - 231, wherein the hydrocarbon diluent comprises a mixture of heavy oil feedstock and at least one of a VGO, MCO, HCO, and mixtures thereof.

239. The process of claims 230 - 231, wherein the emulsion comprises droplets having a size of 0.5 to 200 μm .

10 240. The process of claims 230 - 231, wherein the emulsion comprises droplets having a size of less than 100 μm .

241. The process of claims 230 - 231, wherein providing a metal precursor solution comprising at least a water-soluble molybdenum compound and a water-soluble metal zinc compound in water comprises providing a solution having a concentration of molybdenum in solution of less than 10 wt. %.

20 242. The process of claims 230 - 231, wherein the metal precursor solution comprising at least a water-soluble molybdenum compound and a water-soluble metal zinc compound in water has a concentration of zinc in solution of less than 10 wt. %.

243. The process of claims 230 - 231, wherein the metal precursor solution comprising at least a water-soluble molybdenum compound and a water-soluble metal zinc compound in water has pH of at least 4.

25 244. The process of claims 230 - 231, wherein the slurry catalyst prepared therefrom has a total surface area of at least 100 cm^2/g .

30 245. The process of claims 230 - 231, wherein the slurry catalyst prepared therefrom has a total pore volume of at least 0.4 cc/g and a polymodal pore distribution with at least 70% of pore sizes in the range of 5 to 1,000 Angstroms in diameter.

246. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing a metal precursor solution comprising at least a water-soluble molybdenum salt selected from molybdates, alkali metal heptamolybdates, alkali metal orthomolybdates, alkali metal isomolybdates, phosphomolybdic acid, molybdenum oxide, molybdenum carbide, molybdenum nitride, aluminum molybdate, molybdic acid, and mixtures thereof, and a water-soluble zinc salt, at a zinc to molybdenum weight ratio ranging from 1:30 to 5:1;

mixing the metal precursor solution with a hydrocarbon diluent under high shear mixing and under reducing conditions to generate an emulsion comprising droplets having a size of 0.1 to 300 μm , the hydrocarbon diluent selected from gasoline, diesel, vacuum gas oil (VGO), cycle oil (MCO or HCO), jet oil, fuel oil, heavy oil feedstock, and mixtures thereof;

mixing the emulsion with at least a heavy oil feedstock under in-situ sulfiding conditions for the heavy oil feedstock to provide at least a sulfiding agent to sulfide the emulsion forming a slurry catalyst.

247. The process of claim 246, wherein the slurry catalyst prepared therefrom has an average particle size ranging from 1 to 300 μm .

248. The process of any claims 246 - 247, wherein the emulsion is mixed with the heavy oil feedstock at a temperature from 752°F to 1112°F under a pressure from 1435 psig (10 MPa) to 3610 psig (25 MPa) for in-situ sulfiding to take place.

249. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing a metal precursor solution comprising at least a water-soluble molybdenum salt selected from molybdates, alkali metal heptamolybdates, alkali metal orthomolybdates, alkali metal isomolybdates, phosphomolybdic acid, molybdenum oxide, molybdenum carbide, molybdenum nitride, aluminum molybdate, molybdic acid, and mixtures thereof, and a water-soluble zinc salt, at a zinc to molybdenum weight ratio ranging from 1:30 to 5:1;

providing at least a sulfiding agent to sulfide the metal precursor solution forming a catalyst precursor at a molar ratio of sulfur to molybdenum of at least 1.5 to 1; and

mixing the catalyst precursor with at least a hydrocarbon diluent under reducing conditions forming a slurry catalyst.

250. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing at least a first metal precursor comprising a metal salt of a Primary metal selected from Group VIB metals, Group VIII metals, and Group IIB metals;

5 sulfiding the first metal precursor with a first sulfiding agent at a sulfur to Primary metal of at least 1.5 to 1 to form a sulfided catalyst precursor;

sulfiding the sulfided catalyst precursor with a second sulfiding agent at a molar ratio of sulfur to metal in the sulfided catalyst precursor of at least 1.5 to 1 for an enhanced sulfided catalyst precursor;

10 mixing the enhanced sulfided catalyst precursor with a hydrocarbon diluent forming a slurry catalyst having an average particle size of 1 to 300 μm .

251. The process of claim 250, further comprising:

providing a second metal precursor comprising at least a metal salt of a Promoter metal selected from the group of Group IVB, Group VIB, Group VIII, Group IIB metals and combinations thereof, wherein the Promoter metal is different from the Primary metal;

combining the sulfided catalyst precursor with the second metal precursor for the sulfided catalyst precursor to be promoted with the Promoter metal prior to sulfiding the sulfided catalyst precursor with a second sulfiding agent.

252. The process of claim 251, wherein the Promoter metal is nickel, cobalt, and mixtures thereof.

253. The process of claim 251, wherein the second metal precursor is selected from acetates, carbonates, chlorides, nitrates, actylacetonates, citrates, and oxalates of Group VIII metals.

254. The process of any claims 250 - 251, wherein first metal precursor comprising at least a water-soluble metal salt of a Group VIB metal.

255. The process of any claims 250 - 251, wherein Primary metal is molybdenum the metal salt is selected from the group of molybdates, alkali metal heptamolybdates, alkali metal orthomolybdates, alkali metal isomolybdates, phosphomolybdic acid, molybdenum

oxide, molybdenum carbide, molybdenum nitride, aluminum molybdate, molybdic acid, and mixtures thereof.

256. The process of claim 250, further comprising:

5 providing a second metal precursor comprising at least a metal salt of a Promoter metal selected from Group IVB, Group VIII, Group IIB metals and combinations thereof; combining the second metal precursor into the first metal precursor prior to sulfiding the metal precursor with a first sulfiding agent to form a sulfided catalyst precursor.

10 257. The process of claim 256, wherein the Promoter metal is selected from nickel, cobalt, and mixtures thereof.

15 258. The process of any claims 250 - 251, wherein the Promoter metal is nickel and the Promoter metal salt is selected from the group of nickel acetate, nickel carbonate, nickel chloride, nickel sulfate, nickel nitrate, nickel acetylacetonate, nickel citrate, nickel oxalate, and mixtures thereof.

20 259. The process of any claims 250 - 251, wherein the first sulfiding agent and the second sulfiding agent are selected from the group of elemental sulfur, H_2S , ammonium sulfide, ammonium polysulfide $((NH_4)_2S_x)$, ammonium thiosulfate $((NH_4)_2S_2O_3)$, sodium thiosulfate $(Na_2S_2O_3)$, thiourea (CSN_2H_4) , carbon disulfide, dimethyl disulfide (DMDS), dimethyl sulfide (DMS), tertiarybutyl polysulfide (PSTB) and tertiarynonyl polysulfide (PSTN), and mixtures thereof.

25 260. The process of any claims 250 - 251, wherein the first sulfiding agent is the same as the second sulfiding agent.

30 261. The process of any claims 250 - 251, wherein the first sulfiding agent is different from the second sulfiding agent.

262. The process of any claims 250 - 251, wherein the hydrocarbon diluent is selected from gasoline, diesel, vacuum gas oil (VGO), cycle oil (MCO or HCO), jet oil, fuel oil, heavy oil feedstock, and mixtures thereof.

263. The process of claim 250, wherein the slurry catalyst formed has a general formula of $(M^t)_a(L^u)_b(S^v)_d(C^w)_e(H^x)_f(O^y)_g(N^z)_h$, wherein M is a Primary metal selected from group VIB metals, Group VIII metals, Group IIB metals; L is optional as a Promoter metal and L is different from M, L is at least one of a Group VIII metal, a Group VIB metal, a Group IVB metal, and a Group IIB metal; $b \geq 0$; $0 \leq b/a \leq 5$; $0.5(a+b) \leq d \leq 5(a+b)$; $0 \leq e \leq 11(a+b)$; $0 \leq f \leq 18(a+b)$; $0 \leq g \leq 5(a+b)$; $0 \leq h \leq 3(a+b)$; t, u, v, w, x, y, z, each representing total charge for each of: M, L, S, C, H, O and N, respectively; and $ta+ub+vd+we+xf+yg+zh=0$.

264. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing a first metal precursor comprising water-soluble salt of a Primary metal selected from Group VIB metals, Group VIII metals, and Group IIB metals;

sulfiding the metal precursor with a first sulfiding agent to form a first sulfided precursor;

combining the first sulfided precursor with a second metal precursor comprising a metal salt of a Promoter metal selected from the group of Group VIII metals, Group VIB metals, Group IVB metals, and Group IIB metals, and mixtures thereof wherein the Promoter metal is different from the Primary metal, for a promoted sulfided precursor;

sulfiding the promoted sulfided precursor with a second sulfiding agent at a molar ratio of sulfur to total metals in the promoted sulfided precursor of at least 1.5 to 1 for an enhanced sulfided catalyst precursor;

mixing the enhanced sulfided catalyst precursor with a hydrocarbon diluent forming a slurry catalyst having an average particle size of 1 to 300 μm .

265. The process of claim 264, further comprising subjecting the enhanced sulfided catalyst precursor to reduction at a temperature above ambient.

266. The process of any claims 264 - 265, wherein the Primary metal is molybdenum and the water-soluble salt is selected from the group of molybdates, alkali metal heptamolybdates, alkali metal orthomolybdates, alkali metal isomolybdates, phosphomolybdic acid, molybdenum oxide, molybdenum carbide, molybdenum nitride, aluminum molybdate, molybdic acid, and mixtures thereof.

267. The process of any claims 264 - 265, wherein the Promoter metal is nickel and the Promoter metal salt is selected from the group of nickel acetate, nickel carbonate, nickel chloride, nickel sulfate, nickel nitrate, nickel acetylacetonate, nickel citrate, nickel oxalate, and mixtures thereof.

268. The process of any claims 264 - 265, wherein the hydrocarbon diluent is selected from gasoline, diesel, vacuum gas oil, cycle oil, jet oil, fuel oil, heavy oil feedstock, and mixtures thereof.

269. The process of any claims 264 - 265, wherein the first sulfiding agent and the second sulfiding agent are selected from the group of elemental sulfur, H_2S , ammonium sulfide, ammonium polysulfide ($(NH_4)_2S_x$), ammonium thiosulfate ($(NH_4)_2S_2O_3$), sodium thiosulfate ($Na_2S_2O_3$), thiourea (CSN_2H_4), carbon disulfide, dimethyl disulfide (DMDS), dimethyl sulfide (DMS), tertiarybutyl polysulfide (PSTB) and tertiarynonyl polysulfide (PSTN), and mixtures thereof.

270. In a process for preparing a slurry catalyst for use in upgrading heavy oil feedstock comprising: providing a first metal precursor comprising a Primary metal selected from Group VIB metals and a promoter metal precursor comprising at least a Promoter metal selected from Group IVB metals, Group VIII metals, Group IIB metals and combinations thereof, for a Promoter metal to a Primary metal weight ratio ranging from 1 – 50 wt. %; sulfiding the first metal precursor and the promoter metal precursor separately, concurrently, or together, forming a promoted sulfided catalyst precursor; and mixing the promoted sulfided catalyst precursor with a hydrocarbon diluent forming a slurry catalyst having an average particle size of 1 to 300 μm , the improvement comprising:

apportioning at least one of the metal precursors into a first portion and a second portion at a ratio of first portion to second portion ranging from 1:10 to 10:1;

employing the first portion in the sulfidation step to form the promoted sulfided catalyst precursor; and

mixing the second portion with the promoted sulfided catalyst precursor before, during, or after the mixing step with a hydrocarbon diluent to form the slurry catalyst.

271. The process of claim 270, wherein:
the at least one of the metal precursors apportioned into the first portion and the second portion is the promoter metal precursor.

5 272. The process of claim 271, wherein:
the second portion of the promoter metal precursor is mixed with the promoted sulfided catalyst precursor after the sulfidation step and prior to the mixing step with a hydrocarbon diluent.

10 273. The process of claim 271, wherein:
the second portion of the promoter metal precursor is mixed with the promoted sulfided catalyst precursor during the mixing step with a hydrocarbon diluent.

15 274. The process of claim 271, wherein:
the second portion of the promoter metal precursor is mixed with the promoted sulfided catalyst precursor after to the mixing step with a hydrocarbon diluent.

20 275. The process of claim 271, wherein the sulfiding of the first metal precursor and the promoter metal precursor forming a promoted sulfided catalyst precursor comprises:
sulfiding a mixture of the first metal precursor and the first portion of the promoter metal precursor with at least a sulfiding agent to form the promoted sulfided metal precursor.

25 276. The process of claim 271, wherein the sulfiding of the first metal precursor and the promoter metal precursor forming a promoted sulfided catalyst precursor comprises:
sulfiding the first portion of the promoter metal precursor with at least a sulfiding agent to form a sulfided metal precursor; and
combining the first metal precursor with the sulfided metal precursor to form the promoted sulfided metal precursor.

30 277. The process of claim 271, wherein the sulfiding of the first metal precursor and the promoter metal precursor forming a promoted sulfided catalyst precursor comprises:
sulfiding the first metal precursor with at least a sulfiding agent to form a sulfided metal precursor; and

combining the first portion of the promoter metal precursor with the sulfided metal precursor to form the promoted sulfided metal precursor.

278. The process of claim 270, wherein:

the at least one of the metal precursors is the first metal precursor.

279. The process of claim 278, wherein:

the second portion of the first metal precursor is mixed with the promoted sulfided catalyst precursor after the sulfidation step and prior to the mixing step with a hydrocarbon diluent.

280. The process of claim 278, wherein:

the second portion of the first metal precursor is mixed with the promoted sulfided catalyst precursor during the mixing step with a hydrocarbon diluent.

281. The process of claim 278, wherein:

the second portion of the first metal precursor is mixed with the promoted sulfided catalyst precursor prior to the mixing step with a hydrocarbon diluent.

282. The process of claim 278, wherein the sulfiding of the first metal precursor

and the promoter metal precursor forming a promoted sulfided catalyst precursor comprises: sulfiding a mixture of the first portion of the first metal precursor and the promoter metal precursor with at least a sulfiding agent to form the promoted sulfided metal precursor.

283. The process of claim 278, wherein the sulfiding of the first metal precursor

and the promoter metal precursor forming a promoted sulfided catalyst precursor comprises: sulfiding the promoter metal precursor with at least a sulfiding agent to form a sulfided promoter metal precursor; and

combining the first portion of the first metal precursor with the sulfided promoter metal precursor to form the promoted sulfided metal precursor.

284. The process of claim 278, wherein the sulfiding of the first metal precursor

and the promoter metal precursor forming a promoted sulfided catalyst precursor comprises:

sulfiding the first portion of the first metal precursor with at least a sulfiding agent to form a sulfided metal precursor; and

combining the promoter metal precursor with the sulfided metal precursor metal precursor to form the promoted sulfided metal precursor.

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285. The process of claim 270, wherein the hydrocarbon diluent is selected from gasoline, diesel, vacuum gas oil, cycle oil, jet oil, fuel oil, heavy oil feedstock, and mixtures thereof.

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286. The process of claim 270, wherein the improvement further comprises:
sulfiding the promoted sulfided catalyst precursor with a sulfiding agent for an enhanced sulfiding step before mixing the second portion with the promoted sulfided catalyst precursor before, during, or after the mixing step with a hydrocarbon diluent to form the slurry catalyst.

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287. The process of claim 270, wherein the Primary metal is molybdenum and the first metal precursor is selected from the group of molybdates, alkali metal heptamolybdates, alkali metal orthomolybdates, alkali metal isomolybdates, phosphomolybdic acid, molybdenum oxide, molybdenum carbide, molybdenum nitride, aluminum molybdate, molybdic acid, and mixtures thereof.

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288. The process of claim 270, wherein the Promoter metal is nickel and the promoter metal precursor is selected from the group of nickel acetate, nickel carbonate, nickel chloride, nickel sulfate, nickel nitrate, nickel acetylacetonate, nickel citrate, nickel oxalate, and mixtures thereof.

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289. A process for preparing a slurry catalyst for use in upgrading heavy oil feedstock, comprising:

providing a first metal precursor comprising a water-soluble salt of a Primary metal selected from Group VIB metals;

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providing a promoter metal precursor comprising at least a water-soluble salt of a Promoter metal selected from Group IVB metals, Group VIII metals, Group IIB metals and combinations thereof, for a Promoter metal to Primary metal weight ratio from 1 to 49 wt.

%;

apportioning the promoter metal precursor into a first portion and a second portion at a ratio of first portion to second portion ranging from 1:10 to 10:1;

sulfiding the first metal precursor and the first portion of the promoter metal precursor with a sulfiding agent forming a sulfided catalyst precursor; and

5 mixing the second portion of the promoter metal precursor with the sulfided catalyst precursor forming a promoted sulfided catalyst precursor;

mixing the promoted sulfided catalyst precursor with a hydrocarbon diluent forming a slurry catalyst having an average particle size of 1 to 300 μm .

10 290. The process of claim 289, wherein the mixing of the promoted sulfided catalyst precursor with a hydrocarbon diluent is under reducing conditions in the presence of a reducing agent.