

CLAIMS

5 We claim:

1. A method of producing a supported catalyst, the method comprising:
 - (a) providing a bound zeolite base;
 - (b) washing the bound zeolite base with an aqueous solution comprising an alkali
10 metal to produce an alkali metal enriched zeolite support; and
 - (c) impregnating the alkali metal enriched zeolite support with a transition metal and a halogen to produce the supported catalyst.
2. The method of claim 1, wherein the bound zeolite base comprises a zeolite and a
15 binder.
3. The method of claim 2, wherein the bound zeolite base comprises a weight percentage of binder of from about 3 wt. % to about 35 wt. % based on the total weight of the bound zeolite base.
20
4. The method of any of claims 2 or 3, wherein the binder comprises an inorganic solid oxide, a clay, or a combination thereof.
5. The method of any of claims 2 to 4, wherein the binder comprises alumina, silica,
25 magnesia, boria, titania, zirconia, a mixed oxide thereof, or a mixture thereof.
6. The method of any of claims 2 to 5, wherein the binder comprises silica.
7. The method of any of claims 2 to 6, wherein the binder comprises montmorillonite,
30 kaolin, cement, or a combination thereof.
8. The method of any of claims 1 to 7, wherein the bound zeolite base comprises a bound L-zeolite.

9. The method of any of claims 1 to 7, wherein the bound zeolite base comprises a bound Ba/L-zeolite.
10. The method of any of claims 1 to 7, wherein the bound zeolite base comprises a bound K/L-zeolite.
11. The method of any of claims 1 to 6, wherein the bound zeolite base comprises a silica-bound K/L-zeolite.
12. The method of any of claims 1 to 11, wherein the bound zeolite base in step (a) is produced by a process comprising mixing a zeolite with a binder, extruding the mixture, drying, and calcining.
13. The method of any of claims 1 to 6, wherein the bound zeolite base in step (a) is produced by a process comprising mixing a K/L-zeolite with silica, extruding the mixture, drying, and calcining.
14. The method of any of claims 1 to 13, wherein the method further comprises drying and/or calcining the alkali metal enriched zeolite support prior to step (c).
15. The method of any of claims 1 to 14, wherein the supported catalyst comprises from about 0.1 wt. % to about 10 wt. % transition metal, based on the total weight of the supported catalyst.
16. The method of any of claims 1 to 15, wherein step (c) comprises mixing the alkali metal enriched zeolite support with a transition metal-containing compound comprising tetraamineplatinum(II) chloride, tetraamineplatinum(II) nitrate, platinum(II) acetylacetonate, platinum(II) chloride, ammonium tetrachloroplatinate(II), chloroplatinic acid, platinum (II) nitrate, or a combination thereof.
17. The method of any of claims 1 to 16, wherein the halogen comprises chlorine and/or fluorine.

18. The method of any of claims 1 to 17, wherein step (c) comprises mixing the alkali metal enriched zeolite support with a chlorine-containing compound and/or a fluorine-containing compound.
- 5 19. The method of any of claims 1 to 18, wherein the halogen comprises chlorine.
20. The method of claim 19, wherein the supported catalyst comprises from about 0.05 wt. % to about 5 wt. % chlorine, based on the total weight of the supported catalyst.
- 10 21. The method of any of claims 1 to 18, wherein the halogen comprises fluorine.
22. The method of claim 21, wherein the supported catalyst comprises from about 0.05 wt. % to about 5 wt. % fluorine, based on the total weight of the supported catalyst.
- 15 23. The method of any of claims 1 to 22, wherein the method further comprises drying and/or calcining the supported catalyst after step (c).
24. The method of any of claims 1 to 23, wherein the method the method further comprises a reducing step after step (c), the reducing step comprising contacting the
20 supported catalyst with a reducing gas stream comprising hydrogen.
25. The method of claim 24, wherein the reducing step is conducted at a reducing temperature in a range from about 100 °C to about 700 °C.
- 25 26. The method of any of claims 1 to 25, wherein the supported catalyst has a surface area less than that of a catalyst obtained by washing the bound zeolite base with an aqueous solution that does not contain an alkali metal, under the same catalyst preparation conditions.
27. The method of any of claims 1 to 26, wherein the supported catalyst has a surface area
30 from about 100 m²/g to about 170 m²/g.
28. The method of any of claims 1 to 27, wherein the alkali metal enriched zeolite support has a surface area from about 120 m²/g to about 250 m²/g.

29. The method of any of claims 1 to 28, wherein the supported catalyst has a micropore volume area less than that of a catalyst obtained by washing the bound zeolite base with an aqueous solution that does not contain an alkali metal, under the same catalyst preparation conditions.

5

30. The method of any of claims 1 to 29, wherein the supported catalyst has a micropore volume from about 0.015 cc/g to about 0.05 cc/g.

31. The method of any of claims 1 to 30, wherein the alkali metal enriched zeolite support
10 has a micropore volume from about 0.025 cc/g to about 0.08 cc/g.

32. The method of any of claims 1 to 31, wherein the transition metal comprises platinum.

15 33. The method of any of claims 1 to 32, wherein the supported catalyst comprises from about 0.1 wt. % to about 10 wt. % platinum, based on the total weight of the supported catalyst.

34. The method of any of claims 1 to 33, wherein the supported catalyst is characterized
20 by a T_{EOR} from about 499 °C (930 °F) to about 530 °C (986 °F).

35. The method of any of claims 1 to 34, wherein the supported catalyst is characterized by a benzene selectivity from about 0.91 to about 0.97.

25 36. The method of any of claims 1 to 35, wherein the supported catalyst has a benzene selectivity greater than that of a catalyst obtained by washing the bound zeolite base with an aqueous solution that does not contain an alkali metal, under the same catalyst preparation and aromatization reaction conditions.

30 37. The method of any of claims 1 to 36, wherein the supported catalyst has a platinum dispersion from about 50% to about 70%.

38. The method of any of claims 1 to 37, wherein the supported catalyst comprises from about 10,000 ppmw to about 125,000 ppmw (from about 1 wt. % to about 12.5 wt. %) of the alkali metal disclosed herein based on the total weight of the supported catalyst.

5 39. The method of any of claims 1 to 38, wherein the alkali metal enriched zeolite support comprises any weight percentage of sodium disclosed herein, e.g., from 0 wt. % to about 0.35 wt. %, from 0 wt. % to about 0.3 wt. %, from about 0.03 wt. % to about 0.35 wt. %, or from about 0.05 wt. % to about 0.3 wt. % sodium, based on the total weight of the alkali metal enriched zeolite support.

10

40. The method of any of claims 1 to 39, wherein the aqueous solution comprises an alkali metal salt.

15 41. The method of any of claims 1 to 40, wherein the aqueous solution comprises an alkali metal chloride salt.

42. The method of any of claims 1 to 41, wherein the washing step comprises contacting the bound zeolite base with an aqueous solution consisting essentially of an alkali metal salt and deionized water.

20

43. The method of any of claims 1 to 42, wherein the washing step is conducted at a washing temperature in a range from about 20 °C to about 95 °C.

25 44. The method of any of claims 1 to 43, wherein the washing step includes from 2 to 8 washing cycles; and a washing cycle time period in a range of from about 1 minute to about 6 hours.

45. The method of any of claims 1 to 44, wherein the concentration of the alkali metal in the aqueous solution is from about 0.01 M to about 5 M.

30

46. The method of any of claims 1 to 45, wherein the ratio of the weight of the aqueous solution to the weight of the bound zeolite base is from about 0.4:1 to about 10:1.

47. The method of any of claims 1 to 46, wherein the washing step enriches the bound zeolite base from about 0.03 moles to about 1 mole of alkali metal per kg of the bound zeolite base.

5 48. The method of any of claims 1 to 47, wherein the washing step enriches the bound zeolite base from about 0.03 moles to about 1 mole of alkali metal per kg of the alkali metal enriched zeolite support.

49. The method of any of claims 1 to 48, wherein step (b) is the only step in the method
10 that utilizes an alkali metal.

50. The method of any of claims 1 to 49, wherein step (b) is the only step in the method that utilizes an alkali metal salt.

15 51. The method of any of claims 1 to 50, wherein the alkali metal comprises potassium, rubidium, cesium, or combinations thereof.

52. The method of any of claims 1 to 51, wherein the alkali metal comprises potassium.

20 53. The method of claim 52, wherein the supported catalyst has a surface area in a range from about 100 m²/g to about 170 m²/g and a micropore volume in a range from about 0.015 cc/g to about 0.05 cc/g.

54. The method of claims 52 or 53, wherein:
25 the aqueous solution comprises potassium chloride; or
the aqueous solution further comprises rubidium, cesium, or a combination thereof.

55. The method of any of claims 52 to 54, wherein the concentration of potassium in the aqueous solution is in a range from about 0.1 M to about 0.45 M.

30

56. The method of any of claims 52 to 55, wherein the supported catalyst comprises:
from about 0.2 wt. % to about 5 wt. % platinum;
from about 0.1 wt. % to about 1.5 wt. % fluorine; and
from about 0.1 wt. % to about 1.5 wt. % chlorine;

based on the total weight of the supported catalyst.

57. The method of any of claims 1 to 51, wherein the alkali metal comprises rubidium.

5 58. The method of claim 57, wherein the concentration of rubidium in the aqueous solution is in a range from about 0.01 M to about 5 M.

59. The method of claims 57 or 58, wherein the aqueous solution further comprises potassium, cesium, or a combination thereof.

10

60. The method of any of claims 1 to 51, wherein the alkali metal comprises cesium.

61. The method of claim 60, wherein the concentration of cesium in the aqueous solution is in a range from about 0.01 M to about 5 M.

15

62. The method of claims 60 or 61, wherein:
the aqueous solution further comprises potassium, rubidium, or a combination thereof; and
the supported catalyst comprises from about 5 wt. % to about 30 wt. % of a binder,
20 based on the total weight of the supported catalyst.

63. The method of any of claims 60 to 62, wherein the supported catalyst comprises:
from about 0.2 wt. % to about 5 wt. % transition metal;
from about 0.2 wt. % to about 3 wt. % halogen; and
25 from about 2 wt. % to about 10 wt. % cesium;
based on the total weight of the supported catalyst.

64. A supported catalyst obtained by the method of any of claims 1 to 63.

30 65. The supported catalyst of claim 64, wherein the supported catalyst has a surface area less than that of a catalyst obtained by washing the bound zeolite base with an aqueous solution that does not contain an alkali metal, under the same catalyst preparation conditions.

66. The supported catalyst of claims 64 or 65, wherein the supported catalyst has a surface area from about 100 m²/g to about 170 m²/g.

67. The supported catalyst of any of claims 64 to 66, wherein the alkali metal enriched
5 zeolite support has a surface area from about 120 m²/g to about 250 m²/g.

68. The supported catalyst of any of claims 64 to 67, wherein the supported catalyst has a micropore volume area less than that of a catalyst obtained by washing the bound zeolite base with an aqueous solution that does not contain an alkali metal, under the same catalyst
10 preparation conditions.

69. The supported catalyst of any of claims 64 to 68, wherein the supported catalyst has a micropore volume from about 0.015 cc/g to about 0.05 cc/g.

15 70. The supported catalyst of any of claims 64 to 69, wherein the alkali metal enriched zeolite support has a micropore volume from about 0.025 cc/g to about 0.08 cc/g.

71. The supported catalyst of any of claims 64 to 70, wherein, wherein the transition metal is platinum.

20

72. The supported catalyst of claim 71, wherein the supported catalyst is characterized by a T_{EO}R from about 499 °C (930 °F) to about 530 °C (986 °F).

73. The supported catalyst of claim 71, wherein the supported catalyst has a benzene
25 selectivity from about 0.91 to about 0.97.

74. The supported catalyst of claim 71, wherein the supported catalyst has a benzene selectivity greater than that of a catalyst obtained by washing the bound zeolite base with an aqueous solution that does not contain an alkali metal, under the same catalyst preparation
30 and aromatization reaction conditions.

75. The supported catalyst of claim 71, wherein the supported catalyst has a platinum dispersion from about 50% to about 70%.

76. A reforming process comprising contacting a hydrocarbon feed with the supported aromatization of any one of claims 1 to 75 under reforming conditions in a reactor system to produce an aromatic product.

5 77. The process of Claim 76, wherein the hydrocarbon feed comprises non-aromatic hydrocarbons

78. The process of Claim 76, wherein the hydrocarbon feed comprises C₆-C₈ alkanes and/or cycloalkanes.