CLAIMS

1. A supported catalyst comprising:

a bound zeolite base;

from 0.3 wt. % to 3 wt. % of a transition metal; from 1.8 wt. % to 4 wt. % of chlorine; and

from 0.4 wt. % to 1.5 wt. % of fluorine, based on the total weight of the supported catalyst;

wherein the supported catalyst is characterized by a peak reduction temperature on a Temperature Programmed Reduction (TPR) curve in a range from 580 °F to 800 °F.

2. The catalyst of claim 1, wherein the supported catalyst comprises from 2 wt. % to 3.8 wt. % of chlorine.

3. The catalyst of claim 1 or 2, wherein the supported catalyst comprises from 0.5 wt. % to 1.3 wt. % of fluorine.

4. The catalyst of any one of the preceding claims, wherein the bound zeolite base comprises a zeolite and a binder.

5. The catalyst of claim 4, wherein the supported catalyst comprises from about 5 wt. % to 30 wt. % of the binder, based on the total weight of the supported catalyst.

6. The catalyst of claim 4 or 5, wherein the binder comprises an inorganic solid oxide, a clay, or a combination thereof.

7. The catalyst of claim 4 or 5, wherein the binder comprises alumina, silica, magnesia, boria, titania, zirconia, a mixed oxide thereof, or a mixture thereof.

8. The catalyst of claim 4 or 5, wherein the binder comprises silica.

9. The catalyst of any one of the preceding claims, wherein the supported catalyst comprises a bound L-zeolite.

10. The catalyst of any one of claims 1-9, wherein the supported catalyst comprises a bound barium ion-exchanged L-zeolite.

11. The catalyst of any one of claims 1-9, wherein the supported catalyst comprises a bound K/L-zeolite.

12. The catalyst of any one of claims 1-9, wherein the supported catalyst comprises a silica-bound K/L-zeolite.

13. The catalyst of any one of claims 1-9, wherein the bound zeolite base is produced by a process comprising:

combining a K/L-zeolite with a silica sol to form a mixture;

extruding the mixture to form an extrudate;

drying, and calcining the extrudate to form a calcined base; and

washing, drying, and calcining the calcined base to form the bound zeolite base.

14. The catalyst of any one of the preceding claims, wherein the supported catalyst comprises from 0.5 wt. % to 2 wt. % of the transition metal.

15. The catalyst of any one of the preceding claims, wherein the transition metal comprises platinum.

16. The catalyst of any one of the preceding claims, wherein the supported catalyst comprises from 0.7 wt. % to 1.5 wt. % of platinum.

17. The catalyst of any one of the preceding claims, wherein the supported catalyst is characterized by a peak reduction temperature on a TPR curve in a range from 600 °F to 720 °F.

18. The catalyst of any one of the preceding claims, wherein the supported catalyst is characterized by a TPR curve comprising a lower temperature peak and a higher temperature peak, and wherein the higher temperature peak is greater in height than the lower temperature peak.

19. The catalyst of any one of the preceding claims, wherein the supported catalyst comprises a weight ratio of chlorine:fluorine from 1.5:1 to 8:1.

20. The catalyst of any one of the preceding claims, wherein the supported catalyst has a platinum dispersion that is substantially the same as that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation conditions.

21. The catalyst of any one of the preceding claims, wherein the supported catalyst has a surface area that is substantially the same as that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation conditions.

22. The catalyst of any one of the preceding claims, wherein the supported catalyst has a total nitrogen content that is greater than that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation conditions.

23. The catalyst of any one of the preceding claims, wherein the supported catalyst is characterized by an end of run temperature (TEOR) in a range from about 920 °F to 940 °F.

24. The catalyst of any one of the preceding claims, wherein the supported catalyst is characterized by a TEOR less than that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation and aromatization reaction conditions.

25. The catalyst of any one of the preceding claims, wherein the supported catalyst is characterized by a start of run temperature (TSOR) in a range from 915 °F to 935 °F.

26. The catalyst of any one of the preceding claims, wherein the supported catalyst is characterized by a TSORless than that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation and aromatization reaction conditions.

27. The catalyst of any one of the preceding claims, wherein the supported catalyst is characterized by a Fouling Rate of less than 0.12 °F/min.

28. The catalyst of any one of the preceding claims, wherein the supported catalyst is characterized by a Fouling Rate less than that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation and aromatization reaction conditions.

29. The catalyst of any one of the preceding claims, wherein the supported catalyst is characterized by an aromatics selectivity that is substantially the same as that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation and aromatization reaction conditions.

30. A reforming process comprising contacting a hydrocarbon feed with a supported aromatization catalyst under reforming conditions in a reactor system to produce an aromatic product, wherein the supported aromatization catalyst is the supported catalyst of any one of the preceding claims.

31. The process of claim 30, wherein the hydrocarbon feed comprises C6-C9 alkanes and/or cycloalkanes.

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

(a) impregnating a bound zeolite base with a transition metal precursor, a chlorine precursor, and a fluorine precursor to form an impregnated zeolite base; and

(b) drying and then calcining the impregnated zeolite base to produce the supported catalyst; wherein the supported catalyst comprises, based on the total weight of the supported catalyst:

from 0.3 wt. % to 3 wt. % of a transition metal;

from 1.8 wt. % to 4 wt. % of chlorine; and from 0.4 wt. %
to 1.5 wt. % of fluorine; and
wherein the supported catalyst is characterized by a peak reduction temperature on a Temperature Programmed Reduction curve in a range from about 580 °F to 800 °F.

33. The method of claim 32, wherein the bound zeolite base is produced by a process comprising:
combining a zeolite with a binder to form a mixture;
extruding the mixture to form an extrudate;
drying and calcining the extrudate to form a calcined base; and
washing, drying, and calcining the calcined base to form the bound zeolite base.

34. The method of claim 32 or 33, wherein drying and then calcining the impregnated zeolite base comprises a drying temperature in a range from 50 °C to 200°C at atmospheric pressure or a sub-atmospheric pressure.

35. The method of any one of claims 32-34, wherein drying and then calcining the impregnated zeolite base comprises a peak calcining temperature in a range from 200 °C to 500 °C and a calcining gas stream comprising nitrogen, oxygen, air, or any combination thereof.

36. The method of any one of claims 32-35, wherein impregnating the bound zeolite base with the transition metal precursor comprises mixing the bound zeolite base with the transition metal precursor.

37. The method of any one of claims 32-36, wherein impregnating the bound zeolite base with the chlorine precursor and the fluorine precursor comprises mixing the bound zeolite base with the chlorine precursor and the fluorine precursor.

38. The method of any one of claims 32-35, wherein impregnating the bound zeolite base with the transition metal precursor, chlorine precursor, and fluorine precursor comprises mixing the bound zeolite base with an aqueous solution

comprising the transition metal precursor, the chlorine precursor, and the fluorine precursor.

39. The method of any one of claims 32-38, wherein the supported catalyst comprises from 2 wt. % to 3.8 wt. % of chlorine.

40. The method of any one of claims 32-39, wherein the supported catalyst comprises from 0.5 wt. % to 1.3 wt. % of fluorine.

41. The method of any one of claims 33-40, wherein the supported catalyst comprises from 5 wt. % to 30 wt. % of the binder, based on the total weight of the supported catalyst.

42. The method of any one of claims 33-41, wherein the binder comprises an inorganic solid oxide, a clay, or a combination thereof.

43. The method of any one of claims 33-41, wherein the binder comprises alumina, silica, magnesia, boria, titania, zirconia, a mixed oxide thereof, or a mixture thereof.

44. The method of any one of claims 33-41, wherein the binder comprises silica.

45. The method of any one of claims 32-44, wherein the supported catalyst comprises a bound barium ion-exchanged L-zeolite.

46. The method of any one of claims 32-44, wherein the supported catalyst comprises a bound K/L-zeolite.

47. The method of any one of claims 32-44, wherein the supported catalyst comprises a silica-bound K/L-zeolite.

48. The method of any one of claims 32-47, wherein the supported catalyst comprises from 0.5 wt. % to 2 wt. % of the transition metal.

49. The method of any one of claims 32-48, wherein the transition metal comprises platinum.

50. The method of any one of claims 32-49, wherein the supported catalyst comprises from 0.7 wt. % to 1.5 wt. % of platinum.

51. The method of any one of claims 32-50, wherein the supported catalyst is characterized by a peak reduction temperature on a TPR curve in a range from 600 °F to 720 °F.

52. The method of any one of claims 32-51, wherein the supported catalyst is characterized by a TPR curve comprising a lower temperature peak and a higher temperature peak, and wherein the higher temperature peak is greater in height than the lower temperature peak.

53. The method of any one of claims 32-52, wherein the supported catalyst comprises a weight ratio of chlorine:fluorine from 1.5:1 to 8:1.

54. The method of any one of claims 32-53, wherein the supported catalyst has a platinum dispersion that is substantially the same as that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation conditions.

55. The method of any one of claims 32-54, wherein the supported catalyst has a surface area that is substantially the same as that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation conditions.

56. The method of any one of claims 32-55, wherein the supported catalyst has a total nitrogen content that is greater than that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation conditions.

57. The method of any one of claims 32-56, wherein the supported catalyst is characterized by an end of run temperature (TEOR) in a range from 920 °F to 940 °F.

58. The method of any one of claims 32-57, wherein the supported catalyst is characterized by a TEOR less than that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation and aromatization reaction conditions.

59. The method of any one of claims 32-58, wherein the supported catalyst is characterized by a start of run temperature (TSOR) in a range from 915 °F to 935 °F.

60. The method of any one of claims 32-59, wherein the supported catalyst is characterized by a TSOR less than that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation and aromatization reaction conditions.

61. The method of any one of claims 32-60, wherein the supported catalyst is characterized by a Fouling Rate of less than 0.12 °F/min.

62. The method of any one of claims 32-61, wherein the supported catalyst is characterized by a Fouling Rate less than that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation and aromatization reaction conditions.

63. The method of any one of claims 32-62, wherein the supported catalyst is characterized by an aromatics selectivity that is substantially the same as that of a catalyst having from 0.3 wt. % to 1.5 wt. % chlorine, under the same catalyst preparation and aromatization reaction conditions.

64. The method of any one of claims 32-63, wherein the method further comprises a reducing step after the drying and calcining of the impregnated zeolite base, the reducing step comprising contacting the supported catalyst with a reducing gas stream to produce an activated catalyst.

65. The method of claim 65, wherein the reducing step is conducted at a reducing temperature in a range from 100 °C to 700 °C.

66. A reforming process comprising contacting a hydrocarbon feed with the supported catalyst of claim 64 or the activated catalyst of claim 68 under reforming conditions in a reactor system to produce an aromatic product.

67. The process of claim 66, wherein the hydrocarbon feed comprises C6-C9 alkanes and/or cycloalkanes.