CLAIMS

What is claimed is:

1. A method for separating classes of hydrocarbon compounds from a feed stream, the method comprising the steps of:

passing a feed stream comprising a hydrocarbon mixture through a plurality of separation units ~~arranged in a series in any order~~, the hydrocarbon mixture comprising one or more n-paraffins, one or more iso-paraffins, one or more one-ring cycloparaffins, one or more multi-ring cycloparaffins, and one or more aromatic compounds, wherein each separation unit has ~~an~~ a different adsorbent material; and

separating classes of hydrocarbon compounds from the feed stream,

wherein ~~one of the plurality of separation units~~ a first separation unit comprises ~~an adsorbent material that is~~ a metal organic framework selected from the group consisting of a zirconium-, hafnium-, cerium-, ~~or~~ and titanium-based metal organic framework and generates an extract stream comprising the one or more one-ring cycloparaffins and the one or more multi-ring cycloparaffins;

wherein ~~another of the plurality of separation units has~~ a second separation unit comprises an ~~adsorption~~ adsorbent material ~~that is different from the metal organic framework; and~~ selected from the group consisting of a porous silica, a small pore zeolite, a medium pore zeolite, and a large pore zeolite;

wherein the method is conducted in a liquid phase~~.~~; and

wherein the plurality of separation units are arranged in a series in any order.

~~2. The method of claim 1, wherein the another of the plurality of separation units comprises an adsorbent material that is independently selected from a porous silica, a small pore zeolite, a medium pore zeolite, or a large pore zeolite.~~

~~3.~~2. The method of claim ~~2~~ 1, wherein the porous silica is silica gel, mesoporous organo silica, or clay.

~~4.~~3. The method of claim ~~2~~ 1, wherein the large pore zeolite has a 12 membered or larger ring structure.

~~5.~~4. The method of claim ~~2~~ 1, wherein the large pore zeolite ~~is~~ comprises a framework selected from the group consisting of MWW ~~(MCM-22)~~, MOR ~~(Mordenite)~~, FAU ~~(zeolite 13X, zeolite X, zeolite Y, Siliceous Y)~~, EMT~~(ZSM-3)~~, MAS ~~(ZSM-4)~~, MTW ~~(ZSM-12)~~, MEI ~~(ZSM-18)~~, EMT ~~(ZSM-20)~~, BEA ~~(Beta)~~, LTL ~~(zeolite L)~~, ~~or~~ and DON ~~(UTD-1)~~.

6.5. The method of claim 2 1, wherein the small pore zeolite has an 8 membered ring structure and the medium pore zeolite has a 10 membered ring structure.

7.6. The method of claim 2 1, wherein the small pore zeolite is comprises a framework selected from the group consisting of LTA (ZK-4, zeolite A), or KFI (ZK-5), zeolite A, or zeolite T and ERI, and the medium pore zeolite is comprises a framework selected from the group consisting of MFI (ZSM-5), MEL (ZSM-11), TON (ZSM-22), MTT (ZSM-23), FER (ZSM-35), or and MRE (ZSM-48).

8. The method of claim 2, wherein the hydrocarbon mixture comprises one or more n-paraffins, one or more iso-paraffins, one or more one-ring cycloparaffins, one or more multi-ring cycloparaffins, and one or more aromatic compounds.

9.7. The method of claim 8 1, wherein the feed stream is a refinery stream.

10.8. The method of claim 8 1, wherein the second separation unit comprising an adsorbent material that is comprises the porous silica or the large pore zeolite and generates an extract stream comprising the one or more aromatic compounds.

11. The method of claim 8, wherein the separation unit comprising an adsorbent material that is the metal organic framework generates an extract stream comprising the one or more one-ring cycloparaffins and the one or more multi-ring cycloparaffins.

12.9. The method of claim 8 1, wherein the second separation unit comprising an adsorbent material that is comprises the small pore zeolite or the medium pore zeolite and generates an extract stream comprising the one or more n-paraffins.

13.10. The method of claim 8 1, wherein the another of the plurality of separation units comprises in any order a first second separation unit comprising an adsorbent material that is comprises the porous silica, and wherein a second third separation unit comprising an adsorbent material that is comprises the small pore zeolite or the medium pore zeolite.

14.11. The method of claim 13 10, wherein the method separates the feed stream in any order into (a) a stream comprising the one or more n-paraffins, (b) a stream comprising the one or more iso-paraffins, (c) a stream comprising the one or more one-ring cycloparaffins and the one or more multi-ring cycloparaffins, and (d) a stream comprising the one or more aromatic compounds.

15.12. The method of claim 13 10, wherein the second separation unit comprising an adsorbent material that is the metal organic framework generates an extract stream comprising the one or more one-ring cycloparaffins and the one or more multi-ring cycloparaffins, the separation unit comprising an adsorbent material that is the porous silica generates an

extract stream comprising the one or more aromatic compounds, and the third separation unit comprising ~~an adsorbent material that is~~ the small pore zeolite or the medium pore zeolite generates an extract stream comprising the one or more n-paraffins.

~~16.~~13. The method of claim ~~8~~ 1, wherein the ~~another of the plurality of~~ second separation ~~units~~ unit comprises ~~an adsorbent material that is~~ the porous silica or the large pore zeolite.

~~17. The method of claim 16, wherein the method separates the feed stream in any order into (a) a stream comprising the one or more one-ring cycloparaffins and the one or more multi-ring cycloparaffins, (b) a stream comprising the one or more aromatic compounds, and (c) a stream comprising the one or more n-paraffins and (d) a stream comprising the one or more iso-paraffins.~~

~~18.~~14. The method of claim ~~16~~ 13, wherein the method separates the feed stream in any order into (a) a stream comprising the one or more one-ring cycloparaffins and the one or more multi-ring cycloparaffins, (b) a stream comprising the one or more aromatic compounds, and (c) a stream comprising the one or more n-paraffins and the one or more iso-paraffins.

~~19.~~15. The method of claim ~~8~~ 1, wherein the ~~another of the plurality of~~ second separation ~~units~~ unit comprises ~~an adsorbent material that is~~ the small pore zeolite or the medium pore zeolite.

~~20.~~16. The method of claim ~~19~~ 15, wherein the method separates the feed stream in any order into (a) a stream comprising the one or more n-paraffins, (b) a stream comprising the one or more one-ring cycloparaffins, the one or more multi-ring cycloparaffins, and the one or more aromatic compounds, and (c) a stream comprising the one or more iso-paraffins.

~~21.~~17. The method of claim 1, wherein each of the plurality of separation units is independently selected from the group consisting of a fixed bed apparatus, a moving bed apparatus, a simulated moving bed apparatus, a temperature swing adsorption apparatus, ~~or~~ and a concentration swing adsorption apparatus.

~~22.~~18. The method of claim 1, further comprising desorbing a hydrocarbon compound from an adsorbent material using at least one solvent.

~~23.~~19. The method of claim ~~22~~ 18, wherein the at least one solvent comprises a saturated hydrocarbon, an aromatic hydrocarbon, or mixtures thereof.

~~24.~~20. The method of claim ~~22~~ 18, wherein the at least one solvent is iso-octane, ~~C4-C8~~ C_4-C_8 n-paraffin, hexane, cyclohexane, toluene, benzene, ~~CO2~~ CO_2, ammonia, or mixtures thereof.

~~25.~~21. The method of claim ~~8~~ 1, wherein the one or more multi-ring cycloparaffins comprise one or more two-ring cycloparaffins.

22. A method for separating classes of hydrocarbon compounds from a feed stream, the method comprising the steps of:

passing a feed stream comprising a hydrocarbon mixture through a plurality of separation units, the hydrocarbon mixture comprising one or more n-paraffins, one or more iso-paraffins, one or more one-ring cycloparaffins, one or more multi-ring cycloparaffins, and one or more aromatic compounds, wherein each separation unit has a different adsorbent material; and

separating classes of hydrocarbon compounds from the feed stream,

wherein a first separation unit comprises a metal organic framework selected from the group consisting of a zirconium, hafnium, cerium, and titanium-based metal organic framework and generates an extract stream comprising the one or more one-ring cycloparaffins and the one or more multi-ring cycloparaffins;

wherein a second separation unit comprises a porous silica; wherein a third separation unit comprises a small pore zeolite or a medium pore zeolite;

wherein the method is conducted in a liquid phase, and

wherein the plurality of separation units are arranged in a series in any order.

23. The method of claim 22, wherein the method separates the feed stream in any order into (a) a stream comprising the one or more one-ring cycloparaffins and the one or more multi-ring cycloparaffins, (b) a stream comprising the one or more aromatic compounds, and (c) a stream comprising the one or more n-paraffins and (d) a stream comprising the one or more iso-paraffins.