

CLAIMS

What is claimed is:

1. A method of treating a reactant-lean liquid phase in a process vessel, comprising:
passing the reactant-lean liquid phase and a gas phase co-currently through an exchange layer in the process vessel, wherein the gas phase comprises a reactant; and
diffusing at least some of the reactant from the gas phase into the reactant-lean liquid phase in the exchange layer to form a reactant-rich liquid phase,
wherein the exchange layer comprises a plurality of collector media and a plurality of releaser media, and wherein the collector media comprise porous solid materials capable of collecting the reactant-lean liquid phase within the collector media,
and wherein the releaser media comprise solid materials having a thin film formed on an outer surface thereof that is capable of facilitating contact and diffusion between the reactant-lean liquid phase and the gas phase,
and wherein the thin film is formed on the releaser media during processing as a result of liquid released from the collected liquid phase.
2. The method of claim 1, wherein the process vessel is a trickle bed reactor.
3. The method of claim 1, further comprising passing the reactant-rich liquid phase through a bed of porous solid elements following the exchange layer, the porous solid elements comprising at least one of catalysts, sorbents and reactants.
4. The method of claim 1, further comprising performing a treating process in the process vessel to remove an undesired species from the liquid phase, wherein the treating

process comprises at least one of hydro-desulfurization, hydro-denitrogenation, hydro-cracking, hydrogenation, hydro-dearomatization, hydro-deoxygenation, hydro-demetallization, and isomerization.

5. The method of claim 4, wherein the undesired species comprises at least one of sulfur, nitrogen, oxygen, aromatics, olefins, nickel, vanadium, iron, silicon or arsenic.

6. The method of claim 1, wherein the reactant-rich liquid phase comprises at least one of naphtha, gasoline, kerosene, jet, diesel, gas oils, vegetable oils, animal tallow, and liquid water.

7. The method of claim 1, wherein the reactant diffused from the gas stream into the reactant-lean liquid stream comprises at least one of methane, butane, propane, butalene, propylene, hydrogen, ammonia, hydrogen sulfide, carbon dioxide, carbon monoxide, sulfur oxides, nitrogen oxides, water gas, oxygen, and nitrogen.

8. The method of claim 1, wherein the releaser media comprise at least one of catalysts, sorbents and reactants.

9. The method of claim 8, wherein the size of the releaser media is no more than one-fourth the size of the collector media.

10. The method of claim 8, wherein each of the collector media in the exchange layer has at least twenty contact points on its outer surface that are contacted by releaser media.

11. A method of treating a product-rich liquid phase in a process vessel, comprising:
- passing the product-rich liquid phase and a gas phase co-currently through an exchange layer in the process vessel, wherein the product-rich liquid phase comprises a reaction product; and
 - diffusing at least some of the reaction product from the product-rich liquid phase into the gas in the exchange layer to form a product-lean liquid phase,
 - wherein the exchange layer comprises a plurality of collector media and a plurality of releaser media, and wherein the collector media comprise porous solid materials capable of collecting the product-rich liquid phase within the collector media,
 - and wherein the releaser media comprise solid materials which are capable of facilitating contact and diffusion between the product-rich liquid phase and the gas phase,
 - and wherein the releaser media are no more than one-fourth the size of the collector media,
 - and wherein each of the collector media in the exchange layer has at least twenty contact points on its outer surface that are contacted by releaser media.
12. The method of claim 11, wherein the process vessel is a trickle bed reactor.
13. The method of claim 11, further comprising passing the product-lean liquid phase through a bed of porous solid elements following the exchange layer, the porous solid elements comprising at least one of catalysts, sorbents and reactants.
14. The method of claim 11, further comprising performing a treating process in the process vessel to remove an undesired species from the liquid phase, wherein the treating process comprises at least one of hydro-desulfurization, hydro-denitrogenation, hydro-

cracking, hydrogenation, hydro-dearomatization, hydro-deoxygenation, hydro-demetallization, and isomerization.

15. The method of claim 14, wherein the undesired species comprises at least one of sulfur, nitrogen, oxygen, aromatics, olefins, nickel, vanadium, iron, silicon or arsenic.

16. The method of claim 11, wherein the product-lean liquid phase comprises at least one of naphtha, gasoline, kerosene, jet, diesel, gas oils, vegetable oils, animal tallow, and liquid water.

17. The method of claim 11, wherein the releaser media comprise at least one of catalysts, sorbents and reactants.

18. A method of treating a reactant-lean, product-rich liquid phase in a trickle bed process vessel, comprising:

passing the reactant-lean, product-rich liquid phase and a gas phase co-currently through an exchange layer in the trickle bed process vessel, wherein the gas phase comprises a reactant; and

diffusing at least some of the reaction products from the reactant-lean, product-rich liquid phase into the gas phase and at least some of the reactant from the gas phase into the reactant-lean, product-rich liquid phase in the exchange layer to form a reactant-rich, product-lean liquid phase,

wherein the exchange layer comprises a plurality of collector media and a plurality of releaser media,

and wherein the collector media comprise porous solid materials capable of collecting the reactant-lean liquid phase within the collector media,

and wherein the releaser media comprise solid materials having a thin film formed on an outer surface thereof that is capable of facilitating contact and diffusion between the reactant-lean, product-rich liquid phase and the gas phase,

and wherein the thin film is formed on the releaser media during processing as a result of liquid released from the collected liquid phase.

19. The method of claim 18, further comprising passing the reactant-rich, product-lean liquid phase through a bed of porous solid elements following the exchange layer, the porous solid elements comprising at least one of catalysts, sorbents and reactants.

20. The method of claim 18, further comprising performing a treating process in the process vessel to remove an undesired species from the liquid phase, wherein the treating process comprises at least one of hydro-desulfurization, hydro-denitrogenation, hydro-cracking, hydrogenation, hydro-dearomatization, hydro-deoxygenation, hydro-demetallization, and isomerization.

21. The method of claim 20, wherein the undesired species comprises at least one of sulfur, nitrogen, oxygen, aromatics, olefins, nickel, vanadium, iron, silicon or arsenic.

22. The method of claim 18, wherein the reactant-rich, product-lean liquid phase comprises at least one of naphtha, gasoline, kerosene, jet, diesel, gas oils, vegetable oils, animal tallow, and liquid water.

23. The method of claim 18, wherein the reactant diffused from the gas stream into the reactant-lean, product-rich liquid stream comprises at least one of methane, butane, propane, butalene, propylene, hydrogen, ammonia, hydrogen sulfide, carbon dioxide, carbon monoxide, sulfur oxides, nitrogen oxides, water gas, oxygen, and nitrogen.

24. The method of claim 18, wherein the releaser media comprise at least one of catalysts, sorbents and reactants.

25. The method of claim 24, wherein the size of the releaser media is no more than one-fourth the size of the collector media.

26. The method of claim 24, wherein each of the collector media in the exchange layer has at least twenty contact points on its outer surface that are contacted by releaser media.

27. A trickle bed process vessel for treatment of a reactant-lean, product-rich liquid stream, comprising:

an exchange layer comprising a plurality of collector media and a plurality of releaser media, wherein the exchange layer is capable of facilitating diffusion of one or more reactants from a gas phase into a reactant-lean, product-rich liquid phase within the exchange layer to form a reactant-rich, product-lean liquid phase; and

a treatment layer downstream of the exchange layer comprising a bed of porous solid elements, the porous solid elements comprising at least one of catalysts, sorbents and reactants and capable of performing a treating process to remove an undesired species from the liquid phase, wherein the treating process comprises at least one of hydro-desulfurization,

hydro-denitrogenation, hydro-cracking, hydrogenation, hydro-dearomatization, hydro-deoxygenation, hydro-demetallization, and isomerization,

wherein the collector media and the releaser media are packed within the exchange layer such that each of the collector media has at least twenty contact points on its outer surface that are contacted by releaser media, and wherein the gas phase and the reactant-lean, product-rich liquid phase undergo co-current flow within the exchange layer, and wherein the collector media comprise porous solid materials capable of collecting the reactant-lean liquid phase within the collector media, and wherein the releaser media comprise solid materials having a thin film formed on an outer surface thereof that is capable of facilitating contact and diffusion between the reactant-lean, product-rich liquid phase and the gas phase, and wherein the thin film is formed on the releaser media during processing as a result of liquid released from the collected liquid phase.

28. The process vessel of claim 27, wherein the releaser media comprise at least one of catalysts, sorbents and reactants.

29. The process vessel of claim 27, wherein the size of the releaser media is no more than one-fourth the size of the collector media.

30. The process vessel of claim 27, wherein the undesired species comprises at least one of sulfur, nitrogen, oxygen, aromatics, olefins, nickel, vanadium, iron, silicon or arsenic, and wherein the reactant-rich, product-lean liquid phase comprises at least one of naphtha, gasoline, kerosene, jet, diesel, gas oils, vegetable oils, animal tallow, and liquid water, and wherein the reactant diffused from the gas stream into the reactant-lean, product-rich liquid stream comprises at least one of methane, butane, propane, butalene, propylene, hydrogen,

ammonia, hydrogen sulfide, carbon dioxide, carbon monoxide, sulfur oxides, nitrogen oxides, water gas, oxygen, and nitrogen.