CLAIMS:

1. A process for fractionating a liquid hydrocarbon stream into boiling point fractions, comprising:

providing a liquid hydrocarbon stream;

selecting a first stage membrane effective to separate a liquid hydrocarbon feed into a first stage permeate and a first stage retentate; wherein the heaviest molecule in the first stage permeate has a boiling point in the kerosene boiling range;

selecting a second stage membrane effective to separate a liquid hydrocarbon feed into a second stage permeate and a second stage retentate; wherein the heaviest molecule in the second stage permeate has a boiling point in the diesel boiling range;

selecting a third stage membrane effective to separate a liquid hydrocarbon feed a third stage permeate and a third stage retentate; wherein the heaviest molecule in the third stage permeate has a boiling point in the gas oil boiling range;

selecting a fourth stage membrane effective to separate a liquid hydrocarbon feed into a fourth stage permeate and a fourth stage retentate; wherein the heaviest molecule in the fourth stage permeate has a boiling point in the naphtha boiling range; and

feeding the liquid hydrocarbon stream to one of the first, second, third, ~~or~~ and fourth stage membranes under effective separation conditions;

feeding the applicable stage permeate and retentate to either a downstream refinery process or to another membrane stage; and

repeating the preceding act until each of the first, second, third, and fourth stage membranes has performed a separation on the liquid hydrocarbon stream, permeate from a previous membrane stage, or retentate from a previous membrane stage~~.~~; and

wherein the selecting a membrane for any of the stages comprises:

obtaining compositional data of the liquid hydrocarbon stream; said compositional data comprising one or more of API gravity, average molecular weight, aromaticity, average boiling point, density, total sulfur and nitrogen content, pour point, viscosity, metal content, total acid number (TAN), reid vapor pressure, Micro Carbon Residue content, C7 asphaltenes content, paraffin-naphthene-aromatic content, carbon to hydrogen ratio, and STAR-7 analysis;

determining a desired diffusion of molecules through the membrane;

selecting a membrane based on a relationship of diffusion of molecules through membrane based on temperature, viscosity of the feed, molecular weight and size/radius of molecules;

wherein determining the relationship comprises;

obtaining a liquid hydrocarbon feed of known composition;

obtaining a membrane;

performing a separation experiment by contacting the liquid hydrocarbon feed of known composition with the membrane thereby forming a control permeate and a control retentate;

analyzing the control permeate and the control retentate via one of simulated distillation, elemental analysis, and STAR7 analysis; and

establishing at least one parameter unique to the membrane as an input to relationship of diffusion of molecules on temperature, viscosity, molecular weight and size/radius of molecules.

~~2. The process of claim 1, wherein the selecting a membrane for any of the stages comprises:~~

~~obtaining compositional data of the hydrocarbon stream; said compositional data comprising one or more of API gravity, average molecular weight, aromaticity, average boiling point, density, total sulfur and nitrogen content, pour point, viscosity, metal content, total acid number (TAN), reid vapor pressure, Micro Carbon Residue content, C7 asphaltenes content, paraffin-naphthene-aromatic content, carbon to hydrogen ratio, and STAR-7 analysis;~~

~~determining a desired diffusion of molecules through the membrane;~~

~~selecting a membrane based on a relationship:~~

$$Diffusion\ of\ molecules \propto \frac{kT}{6\pi\ viscosity * Radius}\ function(Radius, MW)$$

~~where k is the Boltzmann constant, T is temperature for separation, viscosity is the viscosity of the feed, radius is the radius of each molecule in the feed, and MW is the molecular weight of each molecule in the feed;~~

~~wherein determining the relationship comprises;~~

~~obtaining a hydrocarbon feed of known composition;~~

~~obtaining a membrane;~~

~~performing a separation experiment by contacting the hydrocarbon feed of known composition with the membrane thereby forming a control permeate and a control retentate;~~

~~analyzing the control permeate and the control retentate via one of simulated distillation, elemental analysis, and STAR7 analysis;~~

~~establishing at least one parameter unique to the membrane as an input to the $function(Radius, MW)$.~~

~~3.~~2. The process of claim ~~2~~ 1, wherein the relationship of diffusion of molecules through the membrane is based on the relationship:

$$Diffusion\ of\ molecules \propto \frac{kT}{6\pi\ viscosity}\left(\frac{1}{Radius}\right)^{a}\left(\frac{1}{MW}\right)^{b}$$

or

$$Diffusion\ of\ molecules \propto \frac{kT}{6\pi\ viscosity * Radius}\left(1-\frac{Radius}{PoreRadius}\right)^{a}\left(\frac{1}{MW}\right)^{b}$$

wherein PoreRadius is the pore size of the membrane, wherein a and b are the parameters unique to the membrane and are established via the relationship ~~$a, b \propto function(MWCO)$.~~ of a, b to Molecular Weight Cut Off (MWCO) of the membrane.

~~4.~~3. The process of claim ~~3~~ 2, wherein the relationship of a, b to ~~$function(MWCO)$~~ is

$$\propto \frac{1}{MWCO}.$$

~~5.~~4. The process of claim 1, wherein the first stage membrane has a ~~MWCO~~ Molecular Weight Cut Off from about 100-500 Daltons.

~~6.~~5. The process of claim 1, wherein the first stage membrane separates via a reverse osmosis modality, a nanofiltration modality, or a combination thereof.

~~7.~~6. The process of claim 1, wherein the second stage membrane has a ~~MWCO~~ Molecular Weight Cut Off from about 500-2000 Daltons.

~~8.~~7. The process of claim 1, wherein the second stage membrane separates via a nanofiltration modality, an ultrafiltration modality, or a combination thereof.

~~9.~~8. The process of claim 1, wherein the third stage membrane has a ~~MWCO~~ Molecular Weight Cut Off from about 2-500 kDaltons, a pore size from 1.5-20 nm, or a combination thereof.

~~10.~~9. The process of claim 1, wherein the third stage membrane has a ~~MWCO~~ Molecular Weight Cut Off from about 2-300 kDaltons.

~~11.~~10. The process of claim 1, wherein the third stage membrane has a ~~MWCO~~ Molecular Weight Cut Off from about 2-50 kDaltons.

~~12.~~11. The process of claim 1, wherein the third stage membrane separates via an ultrafiltration modality.

~~13.~~12. The process of claim 1, wherein the fourth stage membrane has a ~~MWCO~~ Molecular Weight Cut Off of less than 200 Daltons, a pore size less than 1 nm, or a combination thereof.

~~14.~~13. The process of claim 1, wherein the fourth stage membrane separates via a reverse osmosis or pervaporation modality.

~~15.~~14. The process of claim 1, wherein the first stage membrane comprises perfluoropolymers.

~~16.~~15. The process of claim 1, wherein the liquid hydrocarbon stream is pushed through the first stage membrane at a permeate yield from about 5 wt.% to about 75 wt.% of ~~the~~ a whole crude feed.

~~17.~~16. The process of claim 1, wherein the liquid hydrocarbon stream is pushed through the first stage membrane at a permeate yield of about 5 wt.%, about 10 wt.% or about 20 wt.% of ~~the~~ a whole crude feed.

~~18.~~17. The process of claim 1, wherein the first stage retentate is pushed through the second stage membrane at a permeate yield of about 5 wt.% to about 25 wt.% of the first stage retentate.

~~19.~~18. The process of claim 1, wherein the second stage retentate is pushed through the third stage membrane at a permeate yield of about 5 wt.% to about 60 wt.% of the second stage retentate.

~~20.~~19. The process of claim 1, wherein the first stage permeate is pushed through the fourth stage membrane at a permeate yield of about 5 wt.% to about 25 wt.% of the kerosene or naphtha boiling range permeate.

~~21.~~20. The process of claim 1, wherein the liquid hydrocarbon stream is whole crude, ~~topped crude,~~ bitumen, ~~FCC main fractionator feed, coker fractionator feed, hydrocracker fractionator feed, visbreaker fractionator feed,~~ or a combination thereof.

~~22.~~21. The process of claim 1, wherein at least one of the membrane stages comprises a membrane cascade comprising more than one membrane.

~~23.~~22. The process of claim 1, wherein the effective separation conditions comprise a temperature from 25°C - 300°C, feed pressure from 50-2000 psia, permeate pressure from 2-100 psia, and permeate yield from 5 wt.% - 95 wt.%.

~~24. A system for fractionating a hydrocarbon stream into boiling point fractions, comprising:~~

~~a hydrocarbon stream;~~

~~a first stage membrane in fluid communication with the hydrocarbon stream, said first stage membrane effective to separate the hydrocarbon stream into a first stage permeate and a first stage retentate; wherein the heaviest molecule in the first stage permeate has a boiling point in the kerosene boiling range;~~

~~a second stage membrane in fluid communication with the first stage retentate, said second stage membrane effective to separate the first stage retentate into a second~~

stage permeate and a second stage retentate; wherein the heaviest molecule in the second stage permeate has a boiling point in the diesel boiling range;

a third stage membrane in fluid communication with the second stage retentate, said third stage membrane effective to separation the second stage retentate into a third stage permeate and a third stage retentate; wherein the heaviest molecule in the third stage permeate has a boiling point in the gas oil boiling range; and

a fourth stage membrane in fluid communication with the first stage permeate permeate, said fourth stage membrane effective to separate first stage permeate into a fourth stage permeate and a fourth stage retentate; wherein the heaviest molecule in the fourth stage permeate has a boiling point in the naptha boiling range.

25. A process for fractionating a hydrocarbon stream into boiling point fractions, comprising:

providing a hydrocarbon stream;

selecting one or more membranes effective to separate the hydrocarbon stream into a permeate and a retentate stream;

contacting the hydrocarbon stream with the membrane under effective separations conditions; the permeate and retentate streams separated substantially into two separate boiling point fractions;

wherein the selecting the one or more membranes comprises,

obtaining compositional data of the hydrocarbon stream; said compositional data comprising one or more of API gravity, average molecular weight, aromaticity, average boiling point, density, total sulfur and nitrogen content, pour point, viscosity, metal content, total acid number (TAN), reid vapor pressure, Micro Carbon Residue content, C7 asphaltenes content, paraffin-naphthene-aromatic content, carbon to hydrogen ratio, and STAR 7 analysis;

determining a desired diffusion of molecules through the one or more membranes;

selecting one or more membranes based on a relationship:

$$Diffusion\ of\ molecules \propto \frac{kT}{6\pi\ viscosity * Radius}\ function(Radius, MW)$$

where k is the Boltzmann constant, T is temperature for separation, viscosity is the viscosity of the feed, radius is the radius of each molecule in the feed, and MW is the molecular weight of each molecule in the feed;

wherein determining the relationship comprises;

~~obtaining a hydrocarbon feed of known composition;~~

~~obtaining a membrane;~~

~~performing a separation experiment by contacting the hydrocarbon feed of known composition with the membrane thereby forming a control permeate and a control retentate;~~

~~analyzing the control permeate and the control retentate via one of simulated distillation, elemental analysis, and STAR7 analysis;~~

~~establishing at least one parameter unique to the membrane as an input to the $function(Radius, MW)$; and~~

~~repeating the determining the relationship process if more than one membrane is used.~~

~~26. The process of claim 25, wherein the relationship is based on the relationship:~~

$$Diffusion\ of\ molecules \propto \frac{kT}{6\pi\ viscosity}\left(\frac{1}{Radius}\right)^{a}\left(\frac{1}{MW}\right)^{b}$$

~~or~~

$$Diffusion\ of\ molecules \propto \frac{kT}{6\pi\ viscosity * Radius}\left(1-\frac{Radius}{PoreRadius}\right)^{a}\left(\frac{1}{MW}\right)^{b}$$

~~wherein PoreRadius is the pore size of the membrane, wherein a and b are the parameters unique to the membrane and are established via the relationship $a, b \propto function(MWCO)$.~~

~~27. The process of claim 26, wherein $function(MWCO)$ is $\frac{1}{MWCO}$.~~