



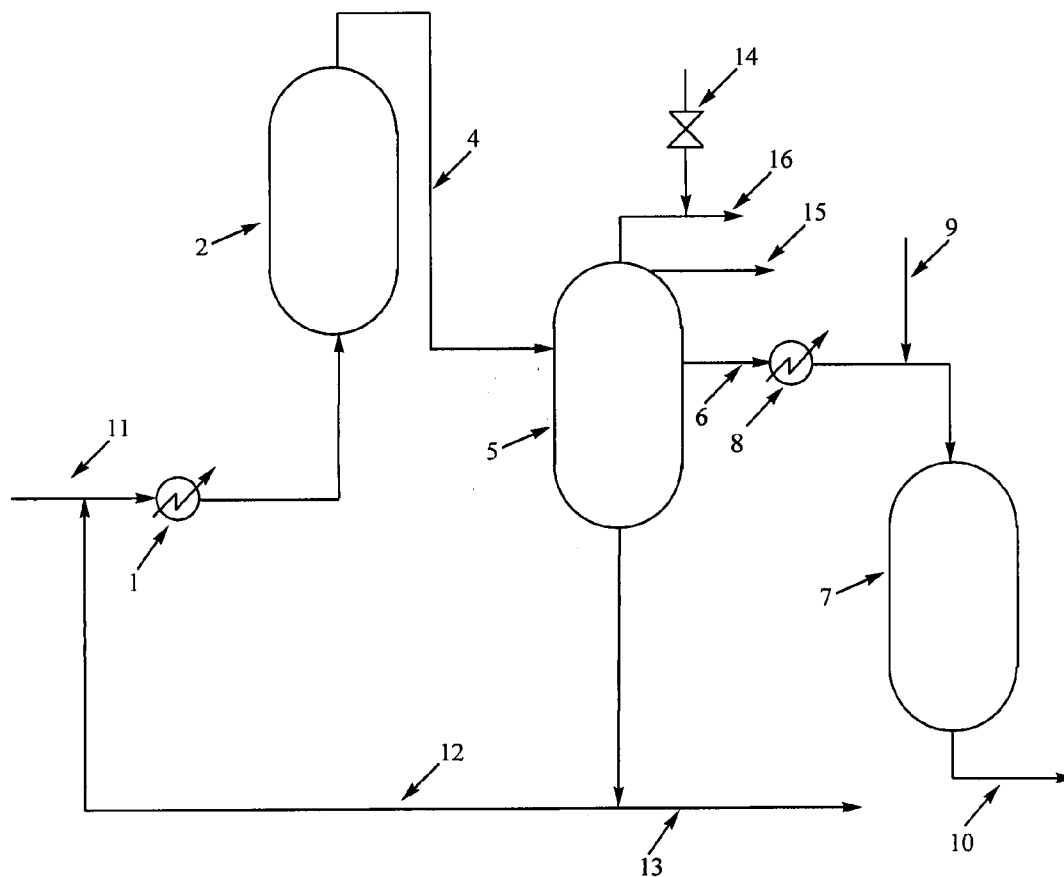
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Petri(10) **Pub. No.: US 2009/0065393 A1**(43) **Pub. Date: Mar. 12, 2009**(54) **FLUID CATALYTIC CRACKING AND
HYDROTREATING PROCESSES FOR
FABRICATING DIESEL FUEL FROM WAXES**(75) Inventor: **John A. Petri, Des Plaines, IL (US)**

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422/189**(57) **ABSTRACT**

A method for obtaining a petroleum distillate product is provided, the method including subjecting a paraffin-based wax, such as a Fisher-Tropsch wax, to the process of cracking at a pressure less than, or equal to, about 7 Kg/cm² in the presence of a first catalyst to obtain an olefinic intermediate, the cracking being carried out in a fluid catalytic cracking apparatus, followed by hydrogenating the olefinic intermediate at a pressure less than, or equal to, about 35 Kg/cm², in the presence of a second catalyst, and recovering the petroleum distillate product. An apparatus for carrying out the method is also provided.



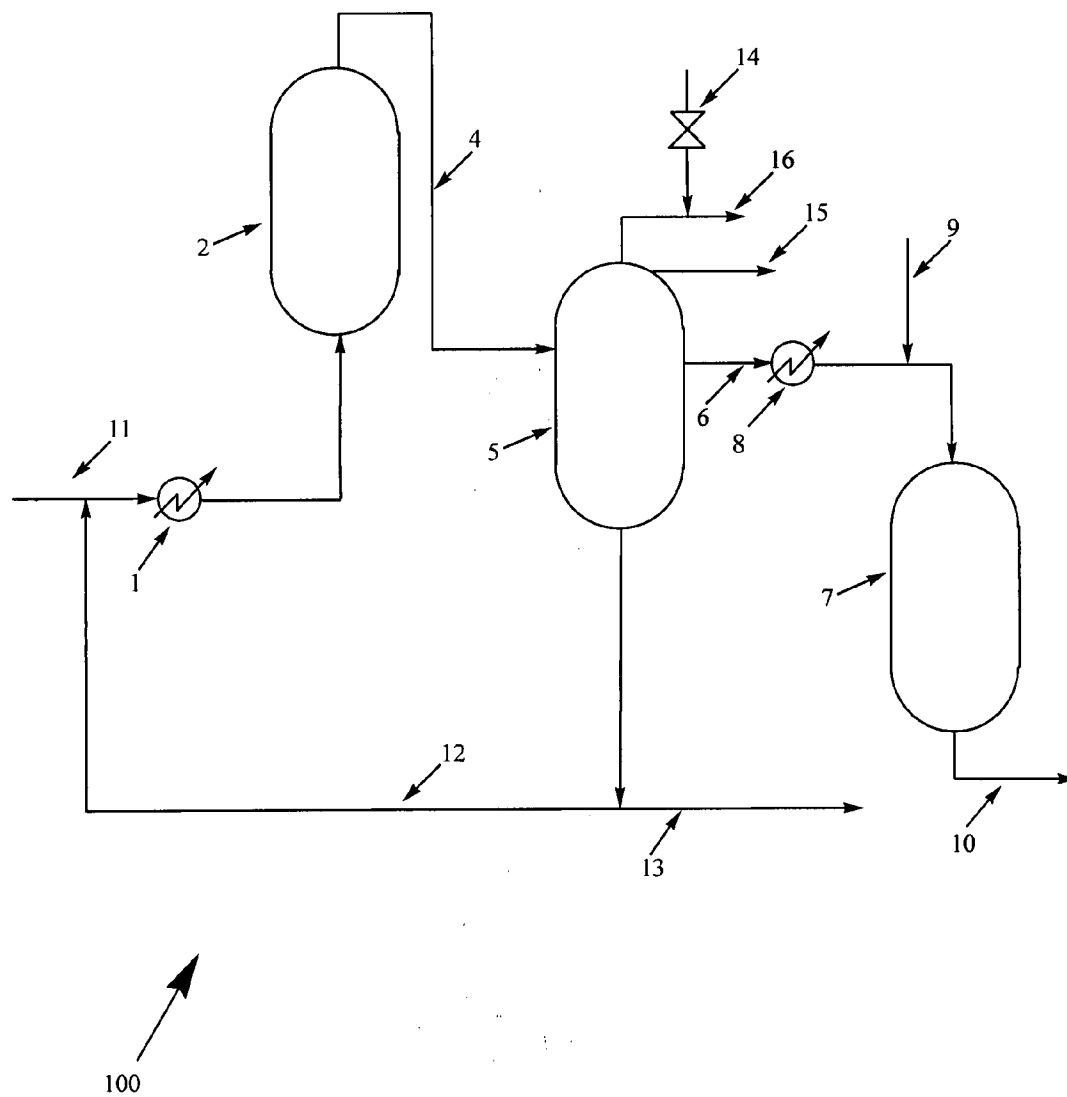


FIG. 1

FLUID CATALYTIC CRACKING AND HYDROTREATING PROCESSES FOR FABRICATING DIESEL FUEL FROM WAXES

TECHNICAL FIELD

[0001] This disclosure relates generally to the processes of fabricating various petroleum-based fuels, and more specifically, to fluid catalytic cracking (FCC) and hydrogenation processes for obtaining petroleum distillate, kerosene and diesel fuel from paraffin-based waxes such as Fischer-Tropsch or slack waxes.

BACKGROUND INFORMATION

[0002] Fischer-Tropsch synthesis is known to yield a broad mixture of products including primarily paraffins, and some olefins. The individual compounds of such mixture can contain up to about 200 carbons, the number of carbons between about 20 and about 150, with average number about 60 being typical. Certain limited quantities of oxygenated products and trace amounts of sulfur- or nitrogen containing products or aromatic compounds can be also present. Such mixtures are known as "Fischer-Tropsch" waxes. Fischer-Tropsch waxes are frequently used as a raw material for obtaining various petrochemical products, such as, e.g., petroleum distillates, kerosene, and diesel fuel, among others.

[0003] Cracking is a process used for breaking complex organic molecules such as heavy hydrocarbons into simpler molecules achieved by the cleaving of carbon-carbon bonds in the precursors, typically in the presence of a catalyst. The rate of cracking and the nature of the end products are dependent on the conditions under which the process is carried out, such as the temperature, the pressure, and the nature of any catalysts used.

[0004] The catalytic cracking process involves the presence of acid catalysts (usually solid acids such as silica-alumina and zeolites) which promote a heterolytic breakage of bonds yielding pairs of ions of opposite charges, usually a carbocation and the very unstable hydride anion. Carbon-localized free radicals and cations are both highly unstable and undergo processes of chain rearrangement, C—C scission in position beta (i.e., cracking) and intra- and intermolecular hydrogen transfer or hydride transfer. In both types of processes, the corresponding reactive intermediates (radicals, ions) are permanently regenerated, and thus they proceed by a self-propagating chain mechanism. The chain of reactions is eventually terminated by radical or ion recombination.

[0005] Fluid catalytic cracking (FCC) is one type of cracking that is widely used. The process typically employs a powdered catalyst having the particles suspended in a rising flow of feed hydrocarbons to form a fluidized bed. One representative catalyst is alumina (aluminum oxide). Also, zeolite-based catalysts are commonly used. In representative processes, cracking takes place in a riser, which is a vertical or upward sloped pipe.

[0006] A pre-heated feed (e.g., a Fischer-Tropsch wax) may be sprayed into the base of the riser via feed nozzles where it contacts hot fluidized catalyst at a temperature between about 650 and about 800° C. The feed is vaporized on contact with the catalyst and the cracking occurs converting the high molecular weight oil into lighter components including liquefied petroleum gas (LPG), gasoline, and a distillate. The catalyst-feed mixture flows upward through the riser for a short period (few seconds) and then the mixture is

separated in cyclones. The hydrocarbons thus separated from the catalyst are directed to a fractionator for separation into LPG, gasoline, diesel, kerosene, jet fuel, etc.

[0007] While going through the riser, the cracking catalyst is used up because the process is accompanied by formation of deposit coke on the catalyst particles. So contaminated catalyst is separated from the cracked hydrocarbon vapors and is further treated with steam to remove hydrocarbons remaining in the catalyst's pores. The catalyst is then directed into a regenerator where the coke is burned off the catalyst particles surface, thus restoring the catalyst's activity and providing the necessary heat for the next reaction cycle. The process of cracking is endothermic. The regenerated catalyst is then used in the new cycle.

[0008] The process of FCC is characterized by certain drawbacks and deficiencies. For example, the process results in the production of a relatively large portion of various olefins, and is accordingly less chemically stable. Olefins in turn form undesirable polymeric deposits in storage tanks, fuel ducts etc.

[0009] Another process that is useful for converting the high molecular weight components in heavy petroleum distillates is catalytic hydrocracking which involves the processes of hydrogenation and carbon-carbon bond cleavage of Fischer-Tropsch waxes in the presence of hydrogen and a catalyst. In this process, at least a majority of oxygen, sulfur, and/or nitrogen-containing compounds, if any are present, can be removed, and olefins are typically saturated to yield paraffins. The process usually requires using very high pressures (such as up to 75 Kg/cm²) and temperatures as high as above about 400° C.

[0010] Despite its many advantages, traditional catalytic hydrocracking is characterized by a number of drawbacks and deficiencies. For example, using high pressures is energy extensive, at times dangerous, and requires the use of specialized machinery. Hydrocracking catalysts are subject to deactivation by both fouling and poisoning, and special measures have to be taken to prevent such deactivation.

[0011] To avoid or lessen the effects of the above-mentioned deficiencies of both FCC and catalytic hydrocracking, as well as for the purposes of improvement of the distillate selectivity and overall process efficiency, better processes are needed to be used with Fischer-Tropsch waxes.

SUMMARY

[0012] We provide methods for obtaining a petroleum distillate product. One method comprises subjecting a paraffin-based wax to the process of cracking at a pressure less than, or equal to, about 7 Kg/cm² in the presence of a first catalyst to obtain an olefinic intermediate, the cracking being carried out in a fluid catalytic cracking apparatus, followed by hydrogenating the olefinic intermediate at a pressure less than, or equal to, about 35 Kg/cm² in the presence of a second catalyst, and recovering the petroleum distillate product.

[0013] The wax subject to cracking may be any wax including a Fischer-Tropsch wax. The wax subject to cracking may also be a slack wax or other materials that are predominantly normal paraffins. The first catalyst, i.e., the catalyst used in the process of cracking, may be a metallic composition embedded within a zeolitic substrate, typically, an amorphous substrate. The metallic composition may comprise a rare earth metal such as scandium, yttrium or a lanthanide series metal—typically referred to as "rare earth" type catalysts. The second catalysts, i.e., the catalyst used in the process of

hydrogenation, may be a base metal composition, such as a nickel-molybdenum composition, a cobalt-molybdenum composition, or the like, or, alternatively, a noble metal composition comprising, for example, platinum, palladium, or the like.

[0014] We also provide a system for obtaining a distillate boiling range product from a paraffin-based wax using a method comprising fluid catalytic cracking and hydrogenating. Such a system comprises a fluidized catalytic cracking reactor for cracking a paraffin-based wax at a pressure less than, or equal to, about 7 Kg/cm² to obtain an olefinic intermediate, a fractionator in fluid connection with the fluid catalytic cracking reactor for recovering a distillate from the olefinic intermediate, and a hydrotreating unit in fluid connection with the fractionator for hydrogenating the distillate to obtain the net reactor effluent comprising of at least about 50 mass % distillate boiling range product.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1 illustrates schematically an apparatus for FCC of Fischer-Tropsch waxes according to one embodiment of the present invention.

DETAILED DESCRIPTION

[0016] The following definitions are used below, unless otherwise described:

[0017] The term “a Fischer-Tropsch wax” is defined as a mixture comprised of predominantly n-paraffins having the number of carbons between about 20 and about 150, the mixture also optionally containing a fraction of oxygenates, and optionally a trace amount of cycloparaffins and/or aromatic compounds.

[0018] The term “a slack wax” is defined as a crude wax produced by chilling and solvent filter-pressing wax distillate.

[0019] The term “catalytic cracking” refers to a process of refining of a hydrocarbon-based feedstock using high temperature and relatively low pressure in the presence of a catalyst, as a result of which heavy and relatively complex hydrocarbons that are present in feedstock are broken down into simpler and lighter hydrocarbons.

[0020] The term “fluid catalytic cracking” or “FCC” refers to a type of catalytic cracking, which employs a catalyst, typically in a form of a powder, having the particles suspended in a rising flow of feed hydrocarbons to form a fluidized bed. The abbreviation “FCC” also refers, where applicable, to the apparatus, i.e., a fluidized catalytic cracking reactor where the process of fluid catalytic cracking is carried out.

[0021] The term “hydrogenation” refers to a process of addition of hydrogen to unsaturated organic compounds, such as olefins (alkenes), typically, in a presence of a suitable catalyst, to obtain saturated organic compounds, such as alkanes, as a result.

[0022] The term “catalyst” is defined as substance that changes the speed or yield of a chemical reaction without being itself substantially consumed or otherwise chemically changed in the process.

[0023] The term “noble metal” refers to a metal that is highly resistant to corrosion or oxidation, and does not easily dissolve, as opposed to most base metals. Examples include, but are not limited to, platinum, palladium, gold, silver, tantalum, or the like.

[0024] The term “base metal” refers to any non-precious metal that is capable of being readily oxidized. Examples include, but are not limited to, nickel, molybdenum, tungsten, cobalt, or the like.

[0025] The term “a metal of lanthanide series” refers to a metal that is one of 14 rare earth elements, with atomic numbers 58 through 71 on the periodic table (i.e., from cerium to lutetium), inclusively.

[0026] The term “a hydrocarbon” is defined as an organic compound, the molecule of which consists only of carbon and hydrogen.

[0027] The term “a paraffin” is defined as a hydrocarbon identified by saturated carbon chains, which can be normal (straight), branched, or cyclic (“cycloparaffin”), and described by a general formula C_nH_{2n+2}, (for straight or branched paraffins), or by a general formula C_nH_{2n}, (for cycloparaffins), where n is an integer.

[0028] The term “an olefin,” also known as “alkene” is defined as a hydrocarbon containing at least one carbon-carbon double bond (C=C), and described by a general formula C_nH_{2n}, where n is an integer.

[0029] The term “a carbonium ion” is defined as an organic cation having one less electron than a corresponding free radical, and having a positive charge that may be, but not necessarily is, localized on the carbon atom.

[0030] The term “distillate” is defined as a petroleum product containing kerosene, jet fuel, diesel fuel and heating oil characterized by boiling ranges set forth in ASTM D-975. “No. 2 distillate” refers to a distillate that meets ASTM D-975 specifications for No. 2 distillate.

[0031] The term “diesel fuel” is defined in accordance with the specifications defined in the American Society for Testing and Materials (ASTM) Specification D 975 and refers to a petroleum fraction having containing primarily C₁₀-C₂₄ hydrocarbons and having distillation temperatures of about 280-340° C. at the 90% recovery point and a flash point greater than about 38° C.

[0032] The term “jet fuel” is defined in accordance with the specifications defined in the ASTM Specification D 1655 and refers to a kerosene-based product having a final maximum boiling point of about 300° C. and a flash point greater than about 38° C.

[0033] The term “kerosene” is defined as a petroleum fraction containing hydrocarbons that are slightly heavier than those found in gasoline and naphtha, such as C₉-C₁₆ hydrocarbons, and having a boiling point at ambient pressure between about 150° C. and about 300° C.

[0034] The term “naphtha” refers to a petroleum fraction with an approximate boiling range between about 25° C. and about 200° C.

[0035] The term “liquefied petroleum gas” or “LPG” refers to a mixture of low-boiling hydrocarbons that exists in a liquid state at ambient temperatures when under moderate pressures which are less than about 1.5 MPa and which comprises principally propane, propylene and butane.

[0036] A distillate product may be obtained by catalytic cracking of a paraffin-based wax, such as a Fischer-Tropsch wax, or, alternatively, a slack wax, followed by hydrogenation. The first stage of the method of the present invention includes using a wax, e.g., a Fischer-Tropsch wax as feedstock and subjecting it to a process of catalytic cracking, which includes exposing the wax to an elevated temperature, as discussed below, in the presence of a catalyst, to form an olefinic intermediate. The process of catalytic cracking may

be carried out in a fluid catalytic cracking apparatus, under mild conditions, as also discussed below.

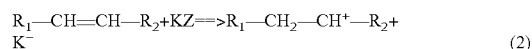
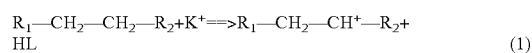
[0037] At the second stage, the olefinic intermediate obtained as described above may be subjected to hydrogenation, which includes reacting the intermediate with hydrogen, an elevated temperature and pressure, which can be also at an elevated level, in the presence of a catalyst. Upon the completion of the process of hydrogenation, the final petroleum distillate may be recovered, the distillate comprising principally a combination of jet fuel and diesel fuel, and in addition, possibly, some quantities of naphtha and/or liquefied petroleum gas (LPG).

[0038] More specifically, as to the first stage, the process of catalytic cracking employs a catalyst that may include a metal. A variety of catalysts may be selected by those having ordinary skill in the art. However, in this invention catalysts that can be used include a metal embedded within a preferably amorphous substrate. The metal that is present in the catalyst may be scandium, yttrium, or one of metals of the lanthanide group series of the periodic chart.

[0039] As mentioned above, the process of catalytic cracking may be carried out in a fluid catalytic cracking apparatus, and under mild conditions, such as the temperature that is less than about 500° C., and pressure that is generally less than, or equal to, about 7 Kg/cm², for example, between about 3 and about 5 Kg/cm². Because of the mild conditions from the lower activity catalyst and lower reaction temperature, the conversion per pass of the wax in the fluidized catalytic cracking apparatus is limited. The limited conversion requires recycling 0-500 mass % of unconverted wax on a fresh feed basis to the fluidized catalytic cracking apparatus. In a typical fluidized catalytic cracking apparatus application, the conditions for catalytic cracking may be more severe. For example, typical reaction temperatures may be greater than about 535° C. and the conversion with a wax may be greater than about 80 mass % in a single pass. Therefore, in a typical cracking application, a wax would be cracked primarily to naphtha and LPG range products. In this invention, conditions are made more mild to effect production of distillate instead of gasoline and LPG.

[0040] The process of catalytic cracking may proceed via various mechanisms. Without being bound by a specific mechanism or theory, one particular set of chemical transformation that is commonly believed to occur involves ionic transformations that can be described as follows.

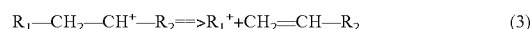
[0041] The first step; initiation, can occur via an alkane (i.e., a paraffin) or an alkene (i.e., an olefin) previously formed from the same or another alkane. The reactions of initiation are schematically shown below as reactions (1) and (2). As can be seen an alkane reacts with the catalyst K in a form of a cation, as in reaction (1), or an alkene reacts with the catalyst K in an acid form, as in reaction (2), yielding in either case a carbocation $R_1-CH_2-CH^+-R_2$:



wherein K is a matrix element of the aluminum oxide-based and/or silicate-based catalyst, L is a Lewis acid or base, and each of R_1 , R_2 , R_3 is an alkyl group.

[0042] Next, the reaction proceeds through the step of propagation (3) where the carbocation $R_1-CH_2-CH^+-R_2$

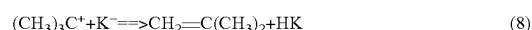
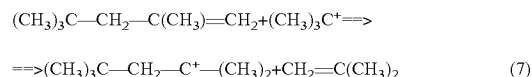
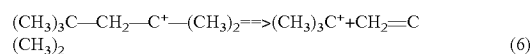
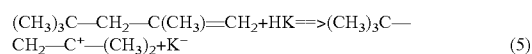
formed at the previous stage breaks down, forming another alkene and thus continues the chain:



[0043] The reaction is terminated by formation of either a lower alkene, as shown by the reaction (4A), where R_3 was part of R_1 , or a lower alkane, as shown by the reaction (4B):



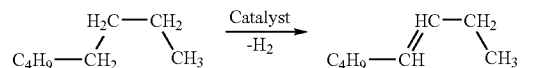
[0044] One example further explaining a possible mechanism of catalytic cracking can utilize a specific alkene, 2,4,4-trimethylpentene-1, where the steps of initiation (5), propagation (6 and 7), and termination (8) result in formation of a simpler alkene, i.e., 2-methylpropene, also known as isobutylene:



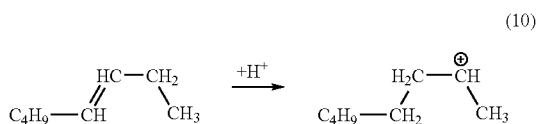
[0045] As can be seen, from the starting alkene, i.e., $(CH_3)_3C-CH_2-C(CH_3)=CH_2$, and the carbocation $(CH_3)_3C-CH_2-C^+-(CH_3)_2$, another molecule of the final product, i.e., isobutylene, is formed, and a carbocation, i.e., $(CH_3)_3C^+$, is also generated, thus allowing the ionic chain to propagate as in reactions (6) and (7). In step (8), another molecule of isobutylene is formed via de-protonation of the carbocation $(CH_3)_3C^+$, and the catalyst HK is regenerated, and is ready to catalyze the step (5) again.

[0046] One typical process of catalytic cracking that is generally within the purview of the processes described above on schemes (1), (3), and (4A) is shown below schematically on the reaction schemes (9)-(12) for the conversion process of Fischer-Tropsch waxes comprised substantially of an n-paraffin. The mechanism of catalytic cracking of an n-paraffin involves formation of a non-stable carbonium ion intermediate.

[0047] More specifically, initially, at the stage of initiation, an olefin is formed as a result of dehydrogenation of an n-paraffin (i.e., n-octane, as shown below) due to the presence of a metal of the catalyst, as shown schematically on the reaction scheme (9):

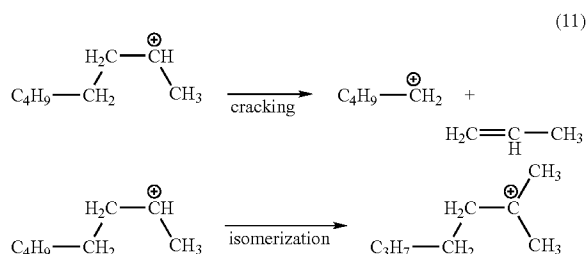


[0048] The olefin formed as shown above then rapidly reacts with the proton that is present at an acid site of the catalyst, followed by rearrangement to form a carbonium ion, as shown below by the reaction scheme (10):

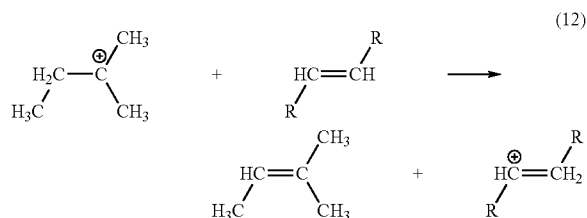


[0049] As can be seen, the reaction scheme (1), above, also demonstrates the formation the same carbocation, but the combination of the processes shown by the reaction schemes (9) and (10) provides a more detailed illustration. The carbonium ion formed as shown by the reaction scheme (10), is very unstable and isomerizes to a different carbonium ion to gain more stability.

[0050] The process of the propagation shown by the reaction scheme (11), generally corresponding to the reaction (3), above, but providing more details, proceeds via the cracking of the original carbonium which occurs at the β -position, to form another cation and an olefin. Secondary cracking, which is also a part of propagation, occurs as the carbonium ion continues to isomerize and crack. These propagation processes, comprising reactions of cracking and isomerization are illustrated schematically by the reaction scheme (11):



[0051] As shown above on the reaction scheme (4A), the process of catalytic cracking is terminated by further transformations of the products obtained at the previous stage, such as formation of an olefin. In the particular illustration of the process started by the reaction (9), the termination stage is shown by the reaction scheme (12) at which point the catalyst is regenerated, and the process started with reaction (9) can begin again:

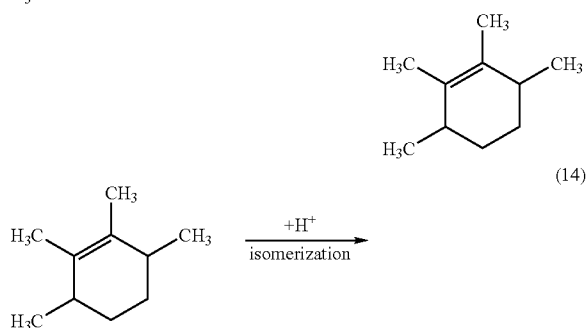
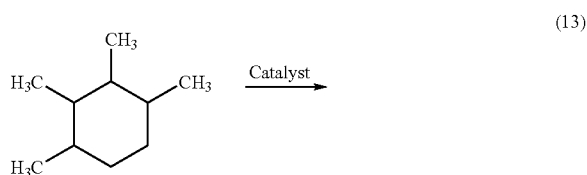


[0052] Waxes useful for conversion can include, in addition to straight-chained and/or branched paraffins, at least some amounts of cycloparaffins, oxygenates and possibly aromatics. In such cases, in addition to the process of conversion of n-paraffin, as shown above, the process of catalytic cracking includes conversion of cycloparaffins, oxygenates and possibly aromatics. One mechanism of conversion of cycloparaffins is shown below schematically on the reaction schemes

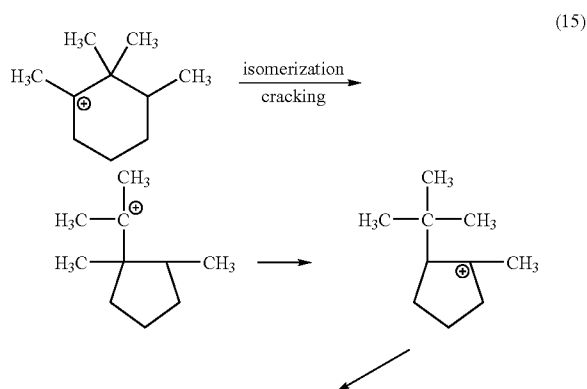
(13)-(15). The mechanism of catalytic cracking of cycloparaffins involves formation of a non-stable carbonium ion intermediate. As a result, an unsaturated cyclic product is formed, to be used in the process of hydrogenation later.

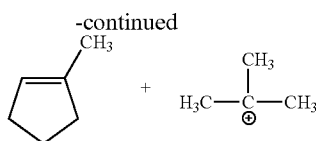
[0053] As can be seen from the reaction schemes (13)-(15), cycloparaffin cracking typically includes cleaving reactions in which certain alkyl groups are selectively removed, while the integrity of the saturated ring itself is preserved. The mechanism of cracking involving cycloparaffins is consistent with the mechanism previously described for normal paraffin cracking. For illustration purposes, the reaction schemes (13)-(15) use 1,2,3,4-tetramethylcyclohexane as the original cycloparaffin.

[0054] As shown below, first, an olefin (i.e., 1,2,3,6-tetramethylcyclohex-ene) is formed followed by the formation of carbonium ions, and by isomerization, as shown on the reaction schemes (13) and (14):



[0055] The carbonium ion so formed then undergoes a series of further steps of isomerization, to yield a cyclic olefin and yet another carbonium ion, as shown on the reaction scheme (15):

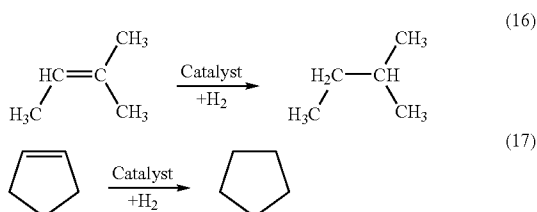




[0056] The above-described process of catalytic cracking is followed by hydrogenation also known in the art as hydrotreating. During hydrogenation, the olefins formed at the cracking stage react with hydrogen, in the presence of a catalyst, and become saturated as a result by forming alkanes. If the original wax contained cycloolefins, in addition cycloalkanes are also formed.

[0057] The process of hydrogenation is carried out in a hydrotreating unit, under mild conditions, such as the temperature between about 250° C. and about 315° C., and pressure that is generally less than, or equal to, about 35 Kg/cm², for example, between about 10 and about 20 Kg/cm². A desired rate of supply of hydrogen gas can be selected. For example, hydrogen gas can be supplied at a rate between about 170 and about 840 m³ per 1 m³ of the olefinic intermediate in the distillate boiling range.

[0058] The process of hydrogenation can be described by the exemplary reaction schemes (16) (for straight-chained olefins such as methylbutene) and (17) (for cycloolefins such as cyclopentene):



[0059] As can be seen from the reaction schemes (16) and (17), the process of hydrogenation is carried out in the presence of a catalyst. An appropriate catalyst can be selected from a variety of available options known in the art. For example, the catalyst that can be used is a base metal composition, such as a nickel-molybdenum composition, a cobalt-molybdenum composition, or the like. Alternatively, or a noble metal composition comprising, for example, platinum, palladium, or the like can be employed.

[0060] Any Fischer-Tropsch wax and/or slack wax can be used as feedstock in the processes described above to form distillate. As discussed above, such a distillate typically contains mid-boiling range hydrocarbons, including a combination (i.e., a mixture) of jet fuel and diesel fuel.

[0061] The specific composition of the reactor effluent from the fluid catalytic cracking apparatus, and the ratio between individual components such as LPG, naphtha and distillate contained therein may depend, among other factors, on the nature and the specific composition of the wax that is used. For example, the reactor effluent from the FCC comprising a combination of jet fuel and diesel fuel, naphtha, and LPG may include more than about 50% by mass of the composition consisting of jet fuel and diesel fuel.

[0062] A variety of waxes may be used in the processes described herein. An acceptable Fischer-Tropsch wax that

can be used may be optionally substantially free of oxygenated species, and the hydrocarbon component is comprised of substantially 100 mass % of a paraffin composition. The paraffin composition may include one or more straight-chained paraffin(s) and may in addition include at least one branched paraffin. Such straight-chained and branched paraffin(s) are the principal components of the paraffin composition. In addition to straight-chained paraffin and branched paraffin(s) the paraffin composition can further comprises at least some quantity of cycloparaffin(s). Trace amounts of alkyl aromatic compounds and polyalkyl aromatic compounds may be also present in the Fischer-Tropsch waxes that can be used in some embodiments.

[0063] Various FCC systems and apparatuses can be used for conducting our processes. One specific example of such a system that can be used is shown by FIG. 1 and can be described as follows.

[0064] The system 100 includes the heat exchanger network 1 which is provided to heat the wax to be cracked to a desired temperature described above, i.e., to a temperature below about 500° C., prior to the introduction of the wax 11 into the fluidized catalytic cracking reactor 2. The fluidized catalytic cracking reactor 2 is the apparatus in which the process of catalytic cracking of the wax in the presence of a fluidized catalyst (not shown) is conducted.

[0065] The desired pressure in reactor 2 is maintained by stream 14 in the overhead of fractionator 5, which is also in communication with reactor 2. The reactor pressure is maintained at the above-described desired level, i.e., at a level of less than, or equal to, about 7 Kg/cm², for example, between about 3 and about 5 Kg/cm². The heated wax 11 and any recycled unconverted wax 12 is introduced into the reactor 2, and the process of catalytic cracking proceeds as generally described above, when the wax comes into contact with the catalyst. Any catalyst that is suitable as a cracking catalyst for the FCC process may be used as previously described above.

[0066] In the process of catalytic cracking, an olefinic intermediate is generated in the reactor 2. The olefinic intermediate 4 is then subjected to further processing. More specifically, the stream of olefinic intermediate 4 is directed to the fractionator 5, where the olefinic intermediate is separated into fractions and the desired fraction(s) of the olefinic intermediate that meet fuel specifications is/are obtained as distillate 6. There exist a variety of fuel specifications. Some of them that can be employed classify the fuel by its flash point and distillation temperatures specified in ASTM T90 or T95, for example. In addition to the distillate, the fractionator 5 also generates a stream of unconverted product 13 and a stream of recycled oil 12, which is unconverted wax. The latter may be combined with the wax 11 in an amount of up to about 500 mass % of the wax feed, thus reducing the conversion per pass of wax in the reactor 2. The process of fractionation is conducted according to standard procedures and protocols and can be varied and adjusted as needed. For example, other fractions may be collected, such as the naphtha fraction 15 and/or the LPG fraction 16.

[0067] Following the process of fractionation, the desired fraction of the olefinic intermediate may be directed as a distillate stream 6, to the hydrotreating unit 7 where it undergoes hydrogenation. The distillate stream 6 may be preliminarily heated to a desired temperature in the heat exchanger network 8. The process of hydrogenation includes reacting the distillate with hydrogen gas 9 on a bed, such as a fixed bed, of a catalyst (not shown).

[0068] Hydrogen may be introduced into the hydrotreating unit 7 as stream 9, and any catalyst suitable as a catalyst of hydrogenation may be used. For example, the above-mentioned base metal composition, such as a nickel-molybdenum composition or a cobalt-molybdenum composition can be used. Alternatively, a noble metal composition, such as a composition comprising platinum or palladium can be also used. The hydrogen may be optionally heated prior to being introduced into the hydrotreating unit 7. Hydrogen is introduced at a rate discussed above, such as at between about 170 and about 840 m³ per 1 m³ of the olefinic intermediate in the distillate boiling range. The process of hydrotreating described above generates the final product, i.e., the hydrotreated distillate(s) which can be then removed as a stream 10 containing the net reactor effluent comprising at least about 50 mass % distillate boiling range product.

[0069] Although our methods and systems have been described with reference to the above-discussed reactions and structures, it will be understood that modifications and variations are encompassed within the spirit and scope of the disclosure as defined in the appended claims.

What is claimed is:

1. A method for obtaining a petroleum distillate product comprising:

- (a) in a fluid catalytic cracking apparatus, cracking a paraffin-based wax at a pressure less than, or equal to, about 7 Kg/cm² in the presence of a first catalyst to obtain an olefinic intermediate;
- (b) hydrogenating the olefinic intermediate in the presence of a second catalyst; and
- (c) recovering the net reactor effluent comprising at least about 50 mass % distillate boiling range product, to obtain the distillate product thereby.

2. The method of claim 1, wherein the wax is at least one selected from the group consisting of a Fisher-Tropsch wax and a slack wax.

3. The method of claim 1, wherein the step of hydrogenating is conducted at a pressure less than, or equal to, about 35 Kg/cm².

4. The method of claim 3, wherein the Fischer-Tropsch wax is comprised of substantially 100 mass % of a paraffin composition.

5. The method of claim 4, wherein the paraffin composition is comprised of at least one straight-chained paraffin and at least one branched paraffin.

6. The method of claim 5, wherein the paraffin composition further comprises at least one cycloparaffin, oxygenate, or aromatic.

7. The method of claim 1, wherein the cracking is carried out at the pressure between about 3 and about 5 Kg/cm².

8. The method of claim 1, wherein the first catalyst comprises a first metallic composition embedded within an amorphous substrate.

9. The method of claim 8, wherein the first metallic composition comprises scandium, yttrium or a metal selected from the lanthanide series of the periodic chart.

10. The method of claim 1, wherein 0 to 500 mass % of unconverted wax is recycled to the fluid catalytic cracking apparatus.

11. The method of claim 1, wherein the second catalyst comprises an amorphous substrate having a second metallic composition impregnated therein

12. The method of claim 11, wherein the amorphous substrate comprises aluminum oxide.

13. The method of claim 11, wherein the second metallic composition comprises a base metal composition or a noble metal composition.

14. The method of claim 13, wherein the base metal composition is at least one selected from the group consisting of a nickel-molybdenum composition and a cobalt-molybdenum composition.

15. The method of claim 13, wherein the noble metal composition comprises at least one noble metal selected from the group consisting of platinum and palladium.

16. The method of claim 1, wherein the distillate boiling range product comprises a combination of jet fuel and diesel fuel.

17. The method of claim 1, wherein the net reactor effluent further comprises naphtha, liquefied petroleum gas or at least one light end product selected from the group consisting of methane, ethane, ethylene, and hydrogen.

18. The method of claim 1, wherein the step of cracking is carried at a temperature that is less than about 500° C.

19. The method of claim 1, wherein the step of hydrogenating is carried at a pressure between about 10 and about 20 Kg/cm².

20. A system for obtaining a distillate boiling range product from a paraffin-based wax, comprising:

- (a) a fluidized catalytic cracking reactor for cracking a paraffin-based wax at a pressure less than, or equal to, about 7 Kg/cm² to obtain an olefinic intermediate;
- (b) a fractionator in fluid connection with the fluid catalytic cracking reactor for recovering a distillate from the olefinic intermediate; and
- (c) a hydrotreating unit in fluid connection with the fractionator for hydrogenating the distillate to obtain the net reactor effluent comprising of at least about 50 mass % petroleum distillate boiling range product.

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