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(54) **FUELS AND LUBRICANTS USING LAYERED  
BED CATALYSTS IN HYDROTREATING  
WAXY FEEDS, INCLUDING  
FISCHER-TROPSCH WAX, PLUS SOLVENT  
DEWAXING**

(76) Inventors: **Stephen J. Miller**, San Francisco, CA  
(US); **Dennis J. O'Rear**, Petaluma, CA  
(US); **John M. Rosenbaum**, Richmond,  
CA (US); **Jerome F. Mayer**, Novato,  
CA (US); **Christopher A. Simmons**, El  
Cerrito, CA (US)

Correspondence Address:  
**Burns, Doane, Swecker & Mathis, L.L.P.**  
**P.O. Box 1404**  
**Alexandria, VA 22313-1404 (US)**

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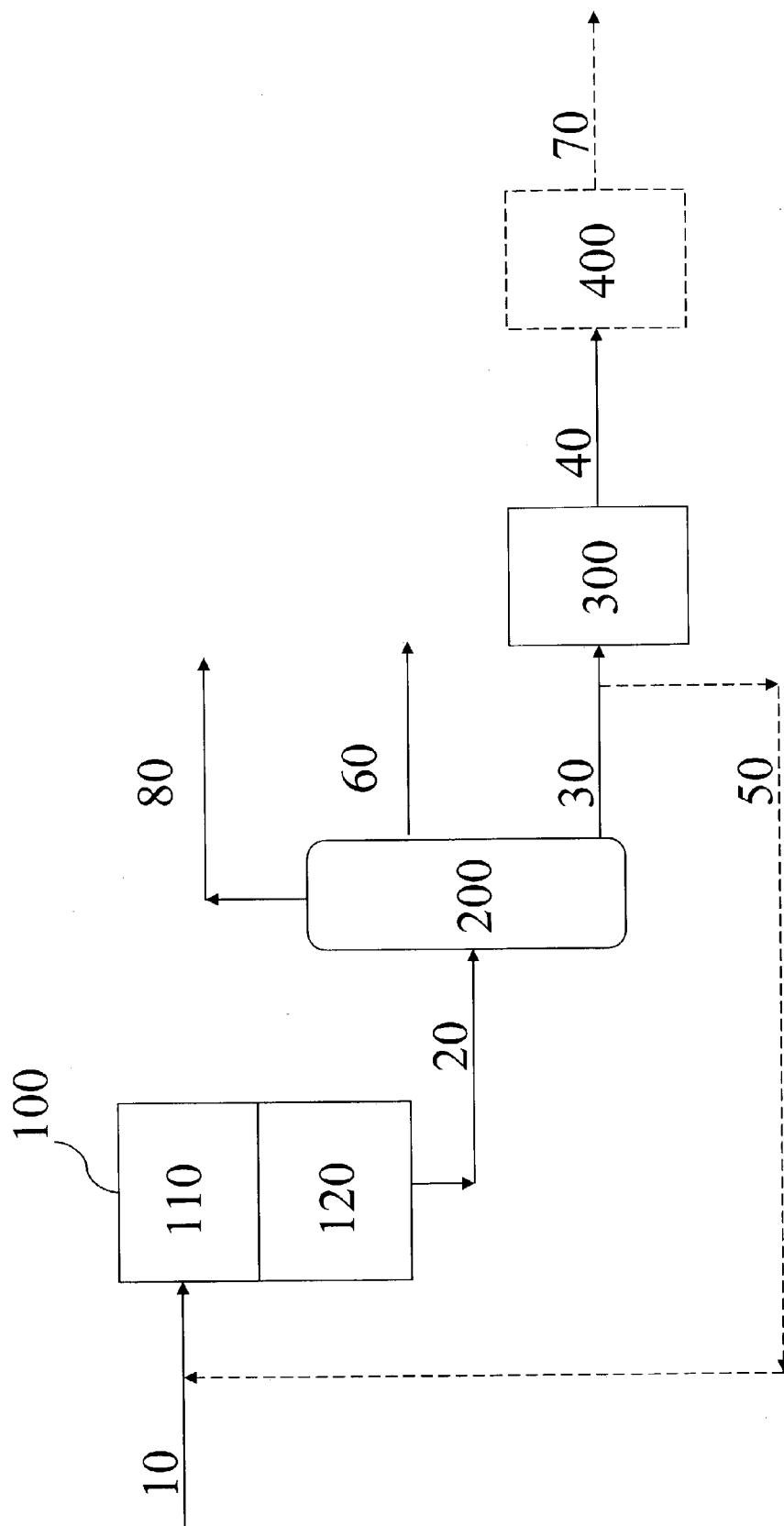
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(57) **ABSTRACT**

Waxy hydrocarbon feedstocks are contacted with a hydro-cracking catalyst and the effluent then contacted with an intermediate pore size molecular sieve hydroisomerization catalyst. The effluent from the hydroisomerization is fractionated to provide a heavy fraction and a middle distillate fuel. At least a portion of the heavy fraction is dewaxed to provide a high quality lubricant base oil with a high viscosity index and a low pour point.

FIGURE



**FUELS AND LUBRICANTS USING LAYERED BED CATALYSTS IN HYDROTREATING WAXY FEEDS, INCLUDING FISCHER-TROPSCH WAX, PLUS SOLVENT DEWAXING**

**FIELD OF THE INVENTION**

[0001] This invention relates to processes for converting waxy hydrocarbon feedstocks into salable products. More particularly, the invention relates to a process of converting a Fischer-Tropsch derived waxy feedstock to middle distillate fuels and lubricant base oils.

**BACKGROUND OF THE INVENTION**

[0002] A Fischer-Tropsch synthesis process may be used to convert a gas composed primarily of CO and H<sub>2</sub> (commonly referred to as synthesis gas or syngas) under catalytic conditions to a wide variety of gaseous, liquid and solid hydrocarbonaceous products. Many of these liquid and solid products contain waxy materials composed of high molecular weight paraffins. These paraffinic waxes can crystallize upon cooling, and products comprising these paraffinic waxes typically have unacceptably high pour points and high cloud points. Pour point is the temperature at which a sample will begin to flow under carefully controlled conditions and may be measured according to ASTM D5950-96. Cloud point is the temperature at which a sample begins to develop a haze under controlled conditions and may be measured according to ASTM D5773-95.

[0003] It is known to catalytically convert waxy paraffins in hydrocarbon feedstocks to lower boiling hydrocarbons within the middle distillate product range. This conversion may be accomplished by hydroprocessing techniques, such as hydrocracking and hydroisomerization. Hydrocracking converts larger molecules into smaller ones and introduces some amount of branching into the cracked products. Hydroisomerization primarily introduces branching into the paraffinic molecules, thus improving properties, such as pour and cloud points. Unreacted components of the hydrocarbon feed, which have not been hydrocracked and/or hydroisomerized, may be recycled for further treatment to provide additional products in the desired boiling range.

[0004] The combination of treating paraffinic hydrocarbon feeds by hydrocracking and hydroisomerization to produce middle distillate hydrocarbons is taught in EP 0544766 B1. EP 0544766 B1 teaches a process for preparing low pour point middle distillate hydrocarbons by contacting a hydrocarbonaceous feedstock with a large pore hydrocracking catalyst and a catalyst comprising an intermediate pore size silicoaluminophosphate molecular sieve and a hydrogenation component.

[0005] U.S. Pat. No. 5,935,414 relates to a process for reducing the wax content of wax-containing hydrocarbon feedstocks to produce middle distillate products, which include a low freeze point jet fuel and/or a low pour point and low cloud point diesel fuel and heating oil. In the process, the feedstock is contacted with a hydrocracking catalyst containing a carrier, at least one hydrogenation metal component of Group VIB and Group VIII metals, and a large pore zeolite such as a Y type zeolite, in a hydrocracking zone in the presence of hydrogen at elevated temperature and pressure. The entire effluent from the hydrocracking zone is contacted with a dewaxing catalyst

containing a crystalline, intermediate pore size molecular sieve selected from metallosilicates and silicoaluminophosphates in a hydrodewaxing zone in the presence of hydrogen at elevated temperature and pressure.

[0006] U.S. Pat. No. 5,139,647 relates to a process for making middle distillates from a hydrocarbonaceous feedstock by a hydrocracking and isomerization. In the process the feedstock is contacted with a catalyst containing an intermediate pore size silicoaluminophosphate molecular sieve and a hydrogenation component.

[0007] U.S. Pat. No. 4,859,312 relates to a process for making middle distillates. The process uses a catalyst comprising a silicoaluminophosphate molecular sieve such as SAPO-11 and SAPO-41, and platinum or palladium, a hydrogenation component, to simultaneously subject heavy oils to hydrocracking and isomerization reactions. The process selectively produces middle distillates in high yields having good low temperature fluid characteristics, especially reduced pour point and viscosity.

[0008] EP 0323092 A2 and U.S. Pat. No. 4,943,672 relate to a process for converting Fischer Tropsch wax into a lubricating oil having a high viscosity index and a low pour point. In the process as disclosed first the wax is hydrotreated under relatively severe conditions and thereafter the hydrotreated wax is hydroisomerized in the presence of hydrogen on a specified type of fluorided Group VIII metal-on-alumina catalyst. The hydroisomerate is then dewaxed to produce a premium lubricating oil base stock.

[0009] U.S. Pat. No. 4,080,397 discloses a method for upgrading a 350° F.+product of Fischer-Tropsch synthesis. In the method as disclosed, the Fischer-Tropsch synthesis product is hydrotreated and the hydrotreated material boiling above about 600° F. is selectively cracked.

[0010] EP 0583836 A1 discloses a process for preparing of hydrocarbon fuels. In the process as disclosed a substantially paraffinic hydrocarbon product is prepared, and the hydrocarbon product is contacted with hydrogen in the presence of a hydroconversion catalyst under conditions such that substantially no isomerization or hydrocracking of the hydrocarbon product occurs. At least a portion of the hydrocarbon product from this process is contacted with hydrogen in the presence of a hydroconversion catalyst under conditions such that hydrocracking and isomerization of the hydrocarbon feed occurs to yield a substantially paraffinic hydrocarbon fuel.

[0011] EP 0147873 A1 discloses a process for preparing middle distillates. Middle distillates are prepared from syngas by a two stage series-flow process. The process comprises a Fischer Tropsch synthesis over a special Zr, Ti, or Cr promoted Co-catalyst followed by hydroconverting the total synthesized product of a Fischer-Tropsch synthesis over a supported noble metal catalyst.

[0012] There remains a need for an efficient and economical process for converting waxy paraffinic feeds to both middle distillate fuels and lubricant base oils in high yields without compromising the desirable properties of the paraffins in the original feed. It is desired that the primary product of the process be lubricant base oil having good low temperature properties (i.e., cloud point, pour point, cold filter plugging point, etc. and high viscosities).

## SUMMARY OF THE INVENTION

[0013] The present invention relates to a process for treating a waxy hydrocarbon feedstock. The process comprises contacting the feedstock with a hydrocracking catalyst in a hydrocracking zone, producing a hydrocracking effluent and contacting the hydrocracking effluent with a molecular sieve hydroisomerization catalyst in a hydroisomerization zone, producing a hydroisomerization effluent. The hydroisomerization effluent is fractionated, providing a heavy fraction and a middle distillate fuel, and at least a portion of the heavy fraction is dewaxed, providing a lubricant base oil. The lubricant base oil from this process has a viscosity index of greater than 130, a pour point of less than  $-15^{\circ}\text{C}$ ., and a viscosity of greater than 3 cSt at  $100^{\circ}\text{C}$ .

[0014] The present invention further relates to a process for treating a  $650^{\circ}\text{F}$ .-waxy hydrocarbon feedstock. The process comprises contacting the feedstock with a hydrocracking catalyst in a hydrocracking zone, producing a hydrocracking effluent, and contacting the hydrocracking effluent with a molecular sieve hydroisomerization catalyst in a hydroisomerization zone, producing a hydroisomerization effluent. The hydroisomerization effluent is fractionated, providing a heavy fraction and a middle distillate fuel; and at least a portion of the heavy fraction is dewaxed, providing a lubricant base oil. The lubricant base oil has a viscosity index of greater than 130, a pour point of less than  $-15^{\circ}\text{C}$ ., and a viscosity of greater than 3 cSt at  $100^{\circ}\text{C}$ . Preferably less than 60 weight % of the  $650^{\circ}\text{F}$ .-components in the feed are converted to  $650^{\circ}\text{F}$ .-products.

[0015] In a further embodiment, the present invention relates to a process for treating a  $650^{\circ}\text{F}$ .-waxy hydrocarbon feedstock. In the process the feedstock is contacted with a hydrocracking catalyst in a hydrocracking zone, producing a hydrocracking effluent; and the hydrocracking effluent is contacted with a molecular sieve hydroisomerization catalyst in a hydroisomerization zone, producing a hydroisomerization effluent. The hydroisomerization effluent is fractionated, providing a heavy fraction and a middle distillate fuel; and at least a portion of the heavy fraction is dewaxed, providing a lubricant base oil. The lubricant base oil produced from this process has a viscosity index of greater than 130, a pour point of less than  $-15^{\circ}\text{C}$ ., and a viscosity of greater than 3 cSt at  $100^{\circ}\text{C}$ ., and the  $650^{\circ}\text{F}$ .-waxy hydrocarbon feedstock comprises greater than 20 weight %  $900^{\circ}\text{F}$ .-components.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIGURE illustrates a schematic representation of one embodiment of the process of the present invention.

## DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0017] The present invention relates to a process for producing high yields of high quality lubricant base oils from waxy hydrocarbon feedstocks. It has been discovered that one can readily and economically convert waxy hydrocarbon feeds having high initial boiling points and containing high levels of paraffinic waxes, such as Fischer Tropsch waxes, into high quality middle distillate fuels and high quality lubricant base oils, with the lubricant base oils being the primary product. In the processes of the present invention these waxy hydrocarbon feeds are contacted with a

hydrocracking catalyst followed by a hydroisomerization catalyst, separated into a middle distillate product and a heavy fraction. The heavy fraction is dewaxed to provide lubricant base oil. This process converts high boiling waxy hydrocarbon feeds into high quality middle distillate fuels with low pour and cloud points and high quality lubricant base oils with high viscosity indexes, and low pour and cloud points. The process of the present invention results in less cracking of the high boiling end of the high boiling waxy feed (i.e., less conversion of the high boiling end of the feed to lighter products). Accordingly, high quality lubricant base oils with high viscosity indexes and low pour and cloud points are produced.

## [0018] Definitions

[0019] The following terms will be used throughout the specification and will have the following meanings unless otherwise indicated.

[0020] "Heavy fraction" is the heavier fraction separated after hydrocracking and hydroisomerization of a waxy hydrocarbon feedstock. The heavy fraction has an initial boiling point in the range of  $600$  to  $750^{\circ}\text{F}$ ., an end boiling point in the range of  $950$  to greater than  $1200^{\circ}\text{F}$ . The heavy fraction comprises lubricant base oil and wax. The heavy fraction may have a wax content between 0.1 and 5 weight percent. A heavy fraction may also be fractionated such that a bottoms fraction is obtained.

[0021] "Bottoms fraction" is a non-vaporized (i.e. residuum) fraction contained as a part of the heavy fraction.

[0022] "Derived from a Fischer-Tropsch synthesis" means that the fuel or product in question originates from or is produced at some stage by a Fischer-Tropsch process.

[0023] "Waxy hydrocarbon feedstock" useful in the processes disclosed herein may be synthetic waxy feedstocks, such as Fischer Tropsch waxy hydrocarbons, or may be derived from natural sources, such as petroleum waxes. The waxy hydrocarbon feedstock contains greater than 50% wax, more preferably greater than about 80% wax, most preferably greater than about 90% wax. As used herein, wax content is determined by a solvent dewaxing process. The solvent dewaxing process is a standard method, and well known in the art. In the process, 300 grams of a waxy product is diluted 50/50 by volume with a 4:1 mixture of methyl ethyl ketone and toluene which had been cooled to  $-20^{\circ}\text{C}$ . The mixture is cooled at a uniform slow rate (in the range of about  $0.5^{\circ}$  to  $4.5^{\circ}\text{C}/\text{min}$ ) to  $-15^{\circ}\text{C}$ ., and then filtered through a Coors funnel at  $-15^{\circ}\text{C}$ . using Whatman No. 3 filter paper. The wax is removed from the filter and placed in a tarred 2 liter flask. Solvent remaining in the wax is removed on a hot plate and the wax weighed.

[0024] " $650^{\circ}\text{F}$ .-waxy hydrocarbon feedstock" has an initial boiling point of  $650^{\circ}\text{F}$ ., wherein at least 70 wt %, preferably at least 85 wt %, of the feedstock boils above  $650^{\circ}\text{F}$ .

[0025] "Middle distillate fuel" or "middle distillate fuel fraction" is the lighter fraction separated after hydrocracking and hydroisomerization of a waxy hydrocarbon feedstock. It is a material containing hydrocarbons with boiling points between approximately  $300^{\circ}\text{F}$ . to  $650^{\circ}\text{F}$ . The term "distillate" means that traditional fuels of this type could be generated from vapor overhead streams from distilling

petroleum crude. Within the broad category of distillate fuels are specific fuels that include naphtha, jet fuel, diesel fuel, kerosene, aviation gas, fuel oil, and blends thereof.

[0026] "Lubricant base oil" means a fraction meeting specifications for a lubricant base oil. Lubricant base oil fractions are provided according to the process of the present invention by dewaxing the heavy fraction. Properties of the lubricant base oils provided according to the present invention include initial boiling points in the range of 600 to 750° F., end boiling points in the range of 900 to greater than 1200° F., viscosities in the range of 3 to 15 cSt at 100° C., viscosity indices in the range of 115 to 180, preferably in the range of 130 to 180, and more preferably in the range of 140 to 180, pour points less than -9° C., preferably in the range of -10 to -24° C., and cloud points in the range of 0 to -20° C.

[0027] "Hydrocarbon or hydrocarbonaceous" means a compound or substance that contains hydrogen and carbon atoms, which may also include heteroatoms such as oxygen, sulfur or nitrogen.

[0028] In the processes according to the present invention, a waxy hydrocarbon feedstock is converted to a middle distillate fuel product and a lubricant base oil product by contacting the feedstock with a hydrocracking catalyst and then a hydroisomerization catalyst. The process according to the present invention provides a lubricant base oil product having a high viscosity index and low pour and cloud points. The process of the present invention results in less cracking of the high boiling end of the high boiling waxy feed (i.e., less conversion of the high boiling end of the feed to lighter products). Accordingly, high quality lubricant base oils with high viscosity indexes and low pour and cloud points are produced.

[0029] The processes as described herein are able to convert the heavy waxy feed to high quality middle distillate products and high quality lubricant base oil products. The waxy hydrocarbon feedstock has an initial boiling point of less than 700° F. The waxy hydrocarbon feedstock has an end boiling point in the range of 1000 to greater than 1200° F. Preferably the waxy hydrocarbon feedstock to the processes as described herein comprises greater than 70 weight percent 650° F.+material, and even more preferably greater than 85 weight percent 650° F.+material. The feed preferably comprises greater than 20 weight percent 900° F.+material

[0030] The waxy feeds to the process of the present invention are comprised of greater than 80 weight % wax, preferably greater than 95 weight % wax. As used herein, wax content is determined by a solvent dewaxing process. The solvent dewaxing process is a standard method, and well known in the art. In the process, 300 grams of a waxy product is diluted 50/50 by volume with a 4:1 mixture of methyl ethyl ketone and toluene which had been cooled to -20° C. The mixture is cooled at a uniform slow rate in the range of about 0.5° to 4.5° C./min to -15° C., and then filtered through a Coors funnel at -15° C. using Whatman No. 3 filter paper. The wax is removed from the filter and placed in a tared 2 liter flask. Solvent remaining in the wax is removed on a hot plate and the wax weighed.

[0031] The waxy hydrocarbon feedstocks useful in the processes disclosed herein may be synthetic waxy feed-

stocks, such as Fischer Tropsch waxy hydrocarbons, or may be derived from natural sources, such as petroleum waxes. Accordingly, the waxy feedstocks to the processes may comprise Fischer Tropsch derived waxy feeds, petroleum waxes, waxy distillate stocks such as gas oils, lubricating oil stocks, high pour point polyalphaolefins, foots oils, normal alpha olefin waxes, slack waxes, deoiled waxes, and microcrystalline waxes, and mixtures thereof. Preferably, the waxy feedstocks are derived from Fischer Tropsch waxy feeds.

[0032] The waxy hydrocarbon feedstock may be hydrotreated prior to the process as described herein if desired. However, for Fischer Tropsch derived waxy feeds hydrotreating is typically not necessary.

[0033] A preferred waxy feed of the present invention is a Fischer-Tropsch derived waxy feed. In Fischer-Tropsch chemistry, syngas is converted to liquid hydrocarbons by contact with a Fischer-Tropsch catalyst under reactive conditions. Typically, methane and optionally heavier hydrocarbons (ethane and heavier) can be sent through a conventional syngas generator to provide synthesis gas. Generally, synthesis gas contains hydrogen and carbon monoxide, and may include minor amounts of carbon dioxide and/or water. The presence of sulfur, nitrogen, halogen, selenium, phosphorus and arsenic contaminants in the syngas is undesirable. For this reason and depending on the quality of the syngas, it is preferred to remove sulfur and other contaminants from the feed before performing the Fischer-Tropsch chemistry. Means for removing these contaminants are well known to those of skill in the art. For example, ZnO guardbeds are preferred for removing sulfur impurities. Means for removing other contaminants are well known to those of skill in the art. It also may be desirable to purify the syngas prior to the Fischer-Tropsch reactor to remove carbon dioxide produced during the syngas reaction and any additional sulfur compounds not already removed. This can be accomplished, for example, by contacting the syngas with a mildly alkaline solution (e.g., aqueous potassium carbonate) in a packed column.

[0034] In the Fischer-Tropsch process, contacting a synthesis gas comprising a mixture of H<sub>2</sub> and CO with a Fischer-Tropsch catalyst under suitable temperature and pressure reactive conditions forms liquid and gaseous hydrocarbons. The Fischer-Tropsch reaction is typically conducted at temperatures of about 300-700° F. (149-371° C.), preferably about 400-550° F. (204-228° C.); pressures of about 10-600 psia, (0.7-41 bars), preferably about 30-300 psia, (2-21 bars); and catalyst space velocities of about 100-10,000 cc/g/hr, preferably about 300-3,000 cc/g/hr. Examples of conditions for performing Fischer-Tropsch type reactions are well known to those of skill in the art.

[0035] The products of the Fischer-Tropsch synthesis process may range from C<sub>1</sub> to C<sub>200+</sub> with a majority in the C<sub>5</sub> to C<sub>100+</sub> range. The reaction can be conducted in a variety of reactor types, such as fixed bed reactors containing one or more catalyst beds, slurry reactors, fluidized bed reactors, or a combination of different type reactors. Such reaction processes and reactors are well known and documented in the literature.

[0036] In general, Fischer-Tropsch catalysts contain a Group VIII transition metal on a metal oxide support. The catalysts may also contain a noble metal promoter(s) and/or

crystalline molecular sieves. Certain catalysts are known to provide chain growth probabilities that are relatively low to moderate, and the reaction products include a relatively high proportion of low molecular ( $C_{2-8}$ ) weight olefins and a relatively low proportion of high molecular weight ( $C_{30+}$ ) waxes. Certain other catalysts are known to provide relatively high chain growth probabilities, and the reaction products include a relatively low proportion of low molecular ( $C_{2-8}$ ) weight olefins and a relatively high proportion of high molecular weight ( $C_{30+}$ ) waxes. Such catalysts are well known to those of skill in the art and can be readily obtained and/or prepared.

[0037] The product from a Fischer-Tropsch process contains predominantly paraffins; however, it may also contain  $C_{2+}$  olefins, oxygenates, and heteroatom impurities. The most abundant oxygenates in Fischer-Tropsch products are alcohols, and mostly primary linear alcohols. Less abundant types of oxygenates in Fischer-Tropsch products include other alcohol types such as secondary alcohols, acids, esters, aldehydes, and ketones. The products from Fischer-Tropsch reactions generally include a light reaction product and a waxy reaction product. The light reaction product (i.e., the condensate fraction) includes hydrocarbons boiling below about 700° F. (e.g., tail gases through middle distillate fuels), largely in the  $C_5$ - $C_{20}$  range, with decreasing amounts up to about  $C_{30}$ . The waxy reaction product (i.e., the wax fraction) includes hydrocarbons boiling above about 600° F. (e.g., vacuum gas oil through heavy paraffins), largely in the  $C_{20+}$  range, with decreasing amounts down to  $C_{10}$ .

[0038] Both the light reaction product and the waxy product are substantially paraffinic. The waxy product generally comprises greater than 70 weight % normal paraffins, and often greater than 80 weight % normal paraffins. The light reaction product comprises paraffinic products with a significant proportion of alcohols and olefins. In some cases, the light reaction product may comprise as much as 50 weight %, and even higher, alcohols and olefins. It is the waxy reaction product (i.e., the wax fraction) that may be used as a feedstock for the processes of the present invention.

[0039] According to the present invention, the waxy hydrocarbon feedstock is contacted with a hydrocracking catalyst in a hydrocracking zone, producing a hydrocracking effluent and the hydrocracking effluent is contacted with a molecular sieve hydroisomerization catalyst in a hydroisomerization zone, producing a hydroisomerization effluent. The hydrocracking catalyst and hydroisomerization catalyst may be arranged in a variety of design options so long as the entire effluent from the hydrocracking zone is passed to the hydroisomerization zone. Accordingly, the hydrocracking and hydroisomerization catalysts may be layered in a single reaction zone in a single reactor, or the hydrocracking and hydroisomerization catalysts may be layered in close-coupled series reactors with no product withdrawal or feed inlet between reactors. The preferred catalyst system is a layered catalyst system, with the hydrocracking catalyst layered above the hydroisomerization catalyst, preferably in a ratio of about 1:1 to 15:1.

[0040] The hydrocracking zone of the process includes a hydrocracking catalyst. During hydrocracking, the high molecular weight wax molecules are cracked into a desirable boiling range. During cracking, at least some of the cracked

molecules may also be isomerized. The resulting cracked product largely comprises a mixture of paraffins and isoparaffins, which boil in the desired fuel or lubricant oil product range. According to the present process, it is desired to minimize the cracking of the feedstock so that a smaller amount of light products will be produced.

[0041] Hydrocracking catalysts are well known to those of skill in the art. Conventional hydrocracking catalysts generally comprise a cracking component, a hydrogenation component and a binder or matrix. Such catalysts are well known in the art

[0042] The matrix component can be of many types including some that have acidic catalytic activity. Ones that have acidic activity include amorphous silica-alumina. The catalyst may also contain a large pore zeolitic or non-zeolitic crystalline molecular sieve, where large pore is defined as having a pore diameter of greater than 7.1 Å. Examples of suitable molecular sieves include zeolite Y, zeolite X and the so called ultra stable zeolite Y and high structural silica:alumina ratio zeolite Y such as that described in U.S. Pat. Nos. 4,401,556, 4,820,402 and 5,059,567. Small crystal size zeolite Y, such as that described in U.S. Pat. No. 5,073,530, can also be used. Non-zeolitic molecular sieves which can be used include, for example, silicoalum inophosphates (SAPO), ferroaluminophosphate, titanium alum inophosphate and the various ELAPO molecular sieves described in U.S. Pat. No. 4,913,799 and the references cited therein. Details regarding the preparation of various non-zeolite molecular sieves can be found in U.S. Pat. Nos. 5,114,563 (SAPO); 4,913,799 and the various references cited in U.S. Pat. No. 4,913,799. Mesoporous molecular sieves can also be used, for example the M41S family of materials (J. Am. Chem. Soc., 114:10834-10843(1992)), MCM-41 (U.S. Pat. Nos. 5,246,689; 5,198,203; 5,334,368), and MCM-48 (Kresge et al., Nature 359:710 (1992)). The contents of each of the patents and publications referred to above are hereby incorporated by reference in their entirety. Preferably, the molecular sieve content of the hydrocracking catalyst is less than 2 wt %.

[0043] Suitable matrix materials may also include synthetic or natural substances as well as inorganic materials such as clay, silica and/or metal oxides such as silica-alumina, silica-magnesia, silica-zirconia, silica-thoria, silica-beryllia, silica-titania as well as ternary compositions, such as silica-alumina-thoria, silica-alumina-zirconia, silica-alumina-magnesia, and silica-magnesia zirconia. The latter may be either naturally occurring or in the form of gelatinous precipitates or gels including mixtures of silica and metal oxides. Naturally occurring clays which can be composited with the catalyst include those of the montmorillonite and kaolin families. These clays can be used in the raw state as originally mined or initially subjected to cation exchange, acid treatment or chemical modification.

[0044] The hydrogenation component will be a Group VI, Group VII, or Group VIII metal or oxide or sulfide thereof, preferably one or more of molybdenum, tungsten, cobalt, or nickel, or the sulfides or oxides thereof. If present in the catalyst, these hydrogenation components generally make up from about 5 weight % to about 40 weight % of the catalyst. Alternatively, platinum group metals, especially platinum and/or palladium, may be present as the hydrogenation component, either alone or in combination with the

base metal hydrogenation components such as molybdenum, tungsten, cobalt, or nickel. If present, the platinum group metals will generally make up from about 0.1 weight % to about 2 weight % of the catalyst. The hydrogenation component can be added to the catalyst by methods such as co-mulling, impregnation, or ion-exchange.

[0045] Typical hydrocracking conditions include: reaction temperature of from about 400 to 950° F. (204 to 510° C.), preferably 600 to 750° F. (316 to 399° C.); reaction pressure of from about 300 to 5000 psig (2.1 to 34.5 MPa), preferably 500 -2000 psig (5.2-13.8 MPa); liquid hourly space velocity (LHSV) of from about 0.1 to 15 hr<sup>-1</sup>, preferably 0.25 to 2.5 hr<sup>-1</sup>; and hydrogen recycle rate of from about 500 to 5000 standard cubic feet (SCF) per barrel of liquid hydrocarbon feed (89.1 to 890 m<sup>3</sup> H<sub>2</sub>/m<sup>3</sup> feed).

[0046] The effluent from the hydrocracking zone is then contacted with an intermediate pore size molecular sieve hydroisomerization catalyst in a hydroisomerization zone.

[0047] The phrase "intermediate pore size," as used herein means an effective pore aperture in the range of from about 4.0 to about 7.1 Å when the porous inorganic oxide is in the calcined form.

[0048] Hydroisomerization dewaxing is intended to improve the cold flow properties of a lubricating base oil by the selective addition of branching into the molecular structure. Hydroisomerization dewaxing ideally will achieve high conversion levels of waxy feed to non-waxy iso-paraffins while at the same time minimizing the conversion by cracking.

[0049] A hydroisomerization dewaxing catalyst useful in the present invention comprises a shape selective intermediate pore size molecular sieve and optionally a catalytically active metal hydrogenation component on a refractory oxide support. The shape selective intermediate pore size molecular sieves used in the practice of the present invention are generally 1-D 10-, 11- or 12-ring molecular sieves. The preferred molecular sieves of the invention are of the 1-D 10-ring variety, where 10- (or 11- or 12-) ring molecular sieves have 10 (or 11 or 12) tetrahedrally-coordinated atoms (T-atoms) joined by oxygens. In the 1-D molecular sieve, the 10-ring (or larger) pores are parallel with each other, and do not interconnect. The classification of intrazeolite channels as 1-D, 2-D and 3-D is set forth by R. M. Barrer in *Zeolites*, Science and Technology, edited by F. R. Rodrigues, L. D. Rollman and C. Naccache, NATO ASI Series, 1984 which classification is incorporated in its entirety by reference (see particularly page 75).

[0050] Preferred shape selective intermediate pore size molecular sieves used for hydroisomerization dewaxing are based upon aluminum phosphates, such as SAPO-11, SAPO-31, and SAPO-41. SAPO-11 and SAPO-31 are more preferred, with SAPO-11 being most preferred. SM-3 is a particularly preferred shape selective intermediate pore size SAPO, which has a crystalline structure falling within that of the SAPO-11 molecular sieves. The preparation of SM-3 and its unique characteristics are described in U.S. Pat. Nos. 4,943,424 and 5,158,665. Also preferred shape selective intermediate pore size molecular sieves used for hydroisomerization dewaxing are zeolites, such as ZSM-22, ZSM-23, ZSM-35, ZSM-48, ZSM-57, SSZ-32, offretite, and ferrierite. SSZ-32 and ZSM-23 are more preferred.

[0051] A particularly preferred intermediate pore size molecular sieve, which is useful in the present process is described, for example, in U.S. Pat. Nos. 5,135,638 and 5,282,958, the contents of which are hereby incorporated by reference in their entirety. In U.S. Pat. No. 5,282,958, such an intermediate pore size molecular sieve has a crystallite size of no more than about 0.5 microns and pores with a minimum diameter of at least about 4.8 Å and with a maximum diameter of about 7.1 Å. The catalyst has sufficient acidity so that 0.5 grams thereof when positioned in a tube reactor converts at least 50% of hexadecane at 370° C., a pressure of 1200 psig, a hydrogen flow of 160 ml/min, and a feed rate of 1 ml/hr. The catalyst also exhibits isomerization selectivity of 40 or greater (isomerization selectivity is determined as follows: 100×(weight % branched C16 in product)/(weight % branched C16 in product+weight % C13-in product) when used under conditions leading to 96% conversion of normal hexadecane (n-C16) to other species.

[0052] Such a particularly preferred molecular sieve may further be characterized by pores or channels having a crystallographic free diameter in the range of from about 4.0 to about 7.1 Å, and preferably in the range of 4.0 to 6.5 Å. The crystallographic free diameters of the channels of molecular sieves are published in the "Atlas of Zeolite Framework Types", Fifth Revised Edition, 2001, by Ch. Baerlocher, W. M. Meier, and D. H. Olson, Elsevier, pp 10-15, which is incorporated herein by reference.

[0053] If the crystallographic free diameters of the channels of a molecular sieve are unknown, the effective pore size of the molecular sieve can be measured using standard adsorption techniques and hydrocarbonaceous compounds of known minimum kinetic diameters. See Breck, *Zeolite Molecular Sieves*, 1974 (especially Chapter 8); Anderson et al. *J. Catalysis* 58, 114 (1979); and U.S. Pat. No. 4,440,871, the pertinent portions of which are incorporated herein by reference. In performing adsorption measurements to determine pore size, standard techniques are used. It is convenient to consider a particular molecule as excluded if it does not reach at least 95% of its equilibrium adsorption value on the molecular sieve in less than about 10 minutes (p/po=0.5; 25° C.). Intermediate pore size molecular sieves will typically admit molecules having kinetic diameters of 5.3 to 6.5 Angstrom with little hindrance.

[0054] Hydroisomerization dewaxing catalysts useful in the present invention optionally comprise a catalytically active hydrogenation metal. The presence of a catalytically active hydrogenation metal leads to product improvement, especially VI and stability. Typical catalytically active hydrogenation metals include chromium, molybdenum, nickel, vanadium, cobalt, tungsten, zinc, platinum, and palladium. The metals platinum and palladium are especially preferred, with platinum most especially preferred. If platinum and/or palladium is used, the total amount of active hydrogenation metal is typically in the range of 0.1 to 5 weight percent of the total catalyst, usually from 0.1 to 2 weight percent, and not to exceed 10 weight percent.

[0055] The refractory oxide support may be selected from those oxide supports which are conventionally used for catalysts, including silica, alumina, silica-alumina, magnesia, titania and combinations thereof.

[0056] The intermediate pore molecular sieve hydroisomerization catalyst is particularly suited for hydroisomer-

izing normal paraffins to produce a low cloud point, low pour point product. Thus, distillate fuel fractions recovered from the hydroisomerization step have reduced cloud points. Furthermore, the hydroisomerization step reduces the pour point of the heavy fraction, and permits at least a portion of the heavy fraction to be recovered for lubricant oils. While it is expected that some cracking conversion will also occur over the hydroisomerization catalyst, the conditions in the hydroisomerization step are maintained such that the hydroisomerization reaction dominates.

**[0057]** With previous hydroisomerization processes, we have found that the cloud point of the lubricant base oil can be high (above 0° C.). While additional isomerization can reduce cloud point, this results in a loss of base oil yield, viscosity index, and viscosity due to cracking and excessive branching.

**[0058]** With this hydrocracking/hydroisomerization process, cracking conversion is minimized while achieving low pour points in the lubricant base oil and middle distillate fuel products. The process of the present invention results in less cracking of the high boiling end of the high boiling waxy feed (i.e., less conversion of the high boiling end of the feed to lighter products). Accordingly, high quality lubricant base oils with high viscosity indexes, low pour points, and higher viscosities are produced. According to the process of the present invention, preferably less than 60 weight percent of the 650° F.+in the feed is converted to 650° F.-products. Therefore, with this process, cracking conversion is minimized while achieving low pour points in the products. In addition, since there is less cracking, high yields of high quality lubricant base oil products are provided.

**[0059]** The product of this hydrocracking/hydroisomerization process is fractionated by conventional methods to provide at least a middle distillate fuel fraction and a heavy fraction. The fractionation can be accomplished by conventional methods of distillation with an appropriate cut point for isolating the middle distillate fuel fraction and heavy fraction.

**[0060]** A portion of the heavy fraction may be recycled to the hydrocracking reaction zone for further reaction, or the heavy fraction may be further fractionated by convention methods, including vacuum distillation, to provide a heavy fraction and a bottoms fraction. The bottoms fraction may be recycled to the hydrocracking reaction zone.

**[0061]** At least a portion of the heavy fraction is dewaxed to provide a lubricant base oil. A solvent dewaxing step may be used in the present invention to remove remaining traces of wax from at least a portion of the heavy fraction to provide a high quality lubricant base oil with a low pour point and a low cloud point.

**[0062]** In a hydrocracking process without a subsequent hydroisomerization step, heavy, unreacted molecules in the product must be recycled for additional cracking until the boiling point range is that of the desired product. In this type of process, the hydrocracking conversions required are quite high in order to achieve the desired fuel production targets, with the cracking being relatively unselective for fuels, and with high amounts of gaseous products being formed. With the addition of a hydroisomerization catalyst according to the process of the invention, product molecules are isomerized as well as cracked. The isomerized product results in

lower pour points, permitting heavier molecules to be included in the diesel boiling range with a resulting increased diesel yield. In addition, isomerized molecules boiling in the lubricant range are recovered as high quality lubricant oils. However, if it were required to remove all traces of wax or normal paraffins from the heavy fraction to provide acceptable cloud points, quite high conversions in the hydrocracking/hydroisomerizing step would continue to be required.

**[0063]** Accordingly, the heavy fraction from the hydrocracking/hydroisomerization step is dewaxed to remove remaining traces of wax or normal paraffins so that lubricant base oils meeting pour and cloud point specifications are provided. Dewaxing permits the hydrocracking to be conducted at milder conditions, since it is not necessary to remove all traces of wax from the heavy fraction in the hydrocracking/hydroisomerization. Therefore, dewaxing the heavy fraction increases production of high quality, high viscosity index lubricant oils.

**[0064]** The dewaxing technique may be chosen based on the amount of residual wax to be removed from the heavy fraction. For example, if the amount of residual wax is small enough, the dewaxing technique may be a relatively mild process. If the amount of wax is slightly greater, traditional dewaxing techniques may be utilized. Solvent dewaxing may be conducted by conventional processes well known to those of skill in the art and may be used to dewax the heavy fraction.

**[0065]** Solvent dewaxing may be accomplished by cooling oil-solvent admixtures under controlled conditions for crystallization of the paraffinic wax present in the admixtures. In such processes, the fractions, or mixtures of fractions and dewaxing solvent, are heated to a temperature at which the wax is dissolved. The heated charge is then passed into a cooling zone wherein cooling is undertaken at a uniform slow rate in the range of about 0.5° to 4.5° C./min until a temperature is reached (e.g. -10° to -20° C.) at which a substantial portion of the wax is crystallized and the dewaxed oil product has a selected pour point temperature. Upon achieving the desired dewaxing temperature, the mixture of wax crystals, oil and solvent is subjected to solid-liquid separation for recovery of a wax free oil-solvent solution and a solid wax containing a minor proportion of oil. Solid-liquid separation techniques, which may be employed for separation of wax crystals from the oil-solvent solutions, include known solid-liquid separation processes, such as gravity settling, centrifugation, and filtration. Most commonly, in commercial processes, filtration in a rotary vacuum filter, followed by solvent wash of the wax cake, is employed. The solid wax/oil solution obtained after separation of the solid wax is known as slack wax.

**[0066]** The separated oil-solvent solution is subjected to distillation for recovery of a solvent fraction and a dewaxed oil product fraction. This process is as described in U.S. Pat. No. 5,413,695, the contents of which are incorporated by reference in their entirety.

**[0067]** Solvents known to be useful as dewaxing solvents are ketones containing 3 to 6 carbon atoms, for example, acetone, methylethyl ketone (MEK), and methylisobutylketone (MIBK), mixtures of ketones, and mixtures of ketones with aromatic hydrocarbons including benzene and toluene. Halogenated low molecular weight hydrocarbons, including

dichloromethane and dichloroethane, and mixtures thereof are also known dewaxing solvents. Solvent dilution of waxy oil stocks maintains fluidity of the oil for facilitating easy handling, for obtaining optimum wax-oil separation, and for obtaining optimum dewaxed oil yields. The extent of solvent dilution depends upon the particular oil stocks and solvents used, the approach to filtration temperature in the cooling zone, and the desired final ratio of solvent to oil in the separation zone.

[0068] Further processes available in the art that may meet the requirements of the dewaxing process of the present invention can include sorbent treating such as clay treating, extraction, catalytic dehazing and the like. A mild catalytic approach in which a catalyst selectively removes the last trace of wax with minimal degradation of the rest of the oil, is taught, for example, in U.S. Pat. No. 4,822,476, the entire disclosure of which is incorporated herein by reference for all purposes. An example sorbent treating process is taught in U.S. Pat. Nos. 6,468,417 and 6,468,418, the entire disclosures of which are incorporated herein by reference for all purposes.

[0069] All or a portion of the wax removed in the dewaxing step may be recovered and recycled to the hydrocracking step for use in the process of the present invention and/or collected for other uses (e.g., for processing into or use as salable wax). When recycling all or a portion of the recovered wax, the wax may be subjected to the hydrocracking step of the present invention alone or may be combined with another paraffinic feedstock. Recycling all or a portion of the recovered wax increases the yield of the process.

[0070] After solvent dewaxing, a lubricant base oil is provided. A higher viscosity lubricant base oil is provided by the processes of the present invention due to less cracking of the high boiling end of the waxy feedstock. Preferably less than 60 weight percent of the 650° F. in the feed is converted to 650° F. products. The lubricant base oil recovered from the process of the present invention has a viscosity index of greater than 130, preferably greater than 140, and more preferably greater than 150. The lubricant base oil provided also has a pour point of less than -15° C. The lubricant base oil has a viscosity of greater than 3 cSt at 100° C., preferably greater than 4 cSt at 100° C., and more preferably greater than 5 cSt at 100° C.

[0071] The recovered lubricant oil may optionally be subjected to hydrofinishing in a mild hydrogenation process to improve its stability to heat and oxidation. The hydrofinishing can be conventionally carried out in the presence of a metallic hydrogenation catalyst such as, for example, platinum on alumina. The hydrofinishing can be carried out at a temperature of from about 190 to about 340° C., a pressure of from about 300 to about 3000 psig (2.76 to 20.7 Mpa), a LHSV between about 0.1 and 20, and hydrogen recycle rates of about 400 to about 1500 SCF/bbl.

[0072] The lubricant base oil recovered from the processes of the present invention may be used as such as a lubricant, or it may be blended with another refined lubricant stock having different properties. Alternatively, the lubricant base oil, prior to use as a lubricant, may be blended with one or more additives, for example, as antioxidants, extreme pressure additives, viscosity index improvers, and the like.

#### [0073] Illustrative Embodiment

[0074] The FIGURE illustrates a schematic representation of one embodiment of the present invention. Referring to the FIGURE, a waxy hydrocarbon feedstock (10) is fed into a single reactor (100) containing a hydrocracking catalyst in a hydrocracking zone (110) and a hydroisomerization catalyst in a hydroisomerization zone (120), wherein the hydrocracking zone (110) is above the hydroisomerization zone (120). The waxy hydrocarbon feedstock (10) is first contacted with the hydrocracking catalyst in the hydrocracking zone (110) and the effluent from the hydrocracking zone (110) is contacted with the hydroisomerization catalyst in the hydroisomerization zone (120). The effluent (20) from the hydroisomerization zone (120) is then fractionated in a fractionator (200), providing a heavy fraction (30), at least a portion of which is subsequently contacted with a dewaxing solvent in a solvent dewaxing unit (300) to remove substantially all of any remaining wax or haze precursors, producing a lubricant oil (40). The lubricant oil has a pour point of less than -15° C., a viscosity index of greater than 130, and a viscosity at 100° C. of greater than 3 cSt. Optionally, a portion of the heavy fraction (30) from the fractionator (200) may be recycled (50) to the hydrocracking zone (110) in the reactor (100). In addition to the heavy fraction (30), the fractionation also produces a middle distillate fuel (60) and a lighter product (80). Finally, the lubricant oil (40) may be optionally hydrofinished in a hydrofinishing unit (400) to provide a hydrofinished lubricant oil (70).

[0075] The invention will now be illustrated by the following examples which is intended to be merely exemplary and in no manner limiting.

### EXAMPLES

#### Comparative Example A

[0076] A light Fischer-Tropsch wax (Table I) was hydrocracked over a dual reactor system of 3/1 (V/V) sulfided nickel-tungsten/silica-alumina catalyst followed by a Pt/SAPO-11 catalyst containing 15% Al<sub>2</sub>O<sub>3</sub> as binder. Operating conditions were 1 hr<sup>-1</sup> overall LHSV, 1000 psig, 680° F. over the Ni—W/SiO<sub>2</sub>—Al<sub>2</sub>O<sub>3</sub> catalyst and 700° F. over the Pt/SAPO-11 catalyst, and 6300 standard cubic feet (SCF)/Bbl once-through H<sub>2</sub>. At these conditions, conversion below 650° F. was 67.5 weight %. Yields and properties of the 650° F.+stripper bottoms are given in Table II.

TABLE I

| Description           | 700–1000° F. Hydrotreated Fischer-Tropsch Wax |
|-----------------------|-----------------------------------------------|
| Gravity, API          | 42.3                                          |
| Sim. Dist. LV %, ° F. |                                               |
| ST/5                  | 691/804                                       |
| 10/30                 | 824/884                                       |
| 50                    | 919                                           |
| 70/90                 | 940/974                                       |
| 95/EP                 | 991/1031                                      |

[0077]

TABLE II

|                                |         |
|--------------------------------|---------|
| Conversion <650° F., Weight %  | 67.5    |
| Yield, Weight %                |         |
| C <sub>1</sub> -C <sub>2</sub> | 0.07    |
| C <sub>3</sub> -C <sub>4</sub> | 8.18    |
| C <sub>5</sub> -180° F.        | 14.32   |
| 180-650° F.                    | 45.46   |
| 650° F.+                       | 32.61   |
| 650° F.+                       |         |
| Weight % of Feed               | 29.1    |
| Pour Point, ° C.               | -14     |
| Cloud Point, ° C.              | -7      |
| Viscosity, 40° C., cSt         | 20.31   |
| 100° C., cSt                   | 4.519   |
| Viscosity Index                | 141     |
| Sim. Dist., LV %, ° F.         |         |
| ST/5                           | 720/742 |
| 10/30                          | 759/818 |
| 50                             | 867     |
| 70/90                          | 907/944 |
| 95/EP                          | 958/984 |

## Example 1

[0078] The feed of Table I was processed over the catalyst system of Comparative Example A at less severe conditions of 1 hr<sup>-1</sup> overall LHSV, 1000 psig, 668° F. over the Ni—W/SiO<sub>2</sub>—Al<sub>2</sub>O<sub>3</sub> catalyst and 687° F. over the Pt/SAPO-11 catalyst, and 6.3 MSCF/Bbl once-through H<sub>2</sub> to give less cracking conversion and a higher pour point in the stripper bottoms. The stripper bottoms were then solvent dewaxed to the same pour point as in Comparative Example A. The solvent dewaxing removes the small amount of wax remaining in the oil, increasing both lubricant oil yield and lubricant oil VI significantly. Results are given in Table III.

TABLE III

|                                        |       |
|----------------------------------------|-------|
| Conversion <650° F., Weight %          | 34.6  |
| Yield, Weight %                        |       |
| C <sub>1</sub> -C <sub>2</sub>         | 0.07  |
| C <sub>3</sub> -C <sub>4</sub>         | 4.17  |
| C <sub>5</sub> -180° F.                | 5.60  |
| 180-650° F.                            | 25.09 |
| 650° F.+                               | 65.56 |
| 650° F.+                               |       |
| Weight % of Feed                       | 62.84 |
| Pour Point, ° C.                       | 8     |
| Cloud Point, ° C.                      | 19    |
| Viscosity, 40° C., cSt                 | 23.16 |
| 100° C., cSt                           | 5.179 |
| Viscosity Index                        | 163   |
| Solvent Dewax                          |       |
| Overall Yield, Wax, Weight %           | 8.76  |
| Overall Yield, Lubricant Oil, Weight % | 54.05 |
| Pour Point, ° C.                       | -14   |
| Cloud Point, ° C.                      | -11   |
| Viscosity, 40° C., cSt                 | 22.27 |
| 100° C., cSt                           | 5.022 |
| Viscosity Index                        | 160   |

TABLE III-continued

| Sim. Dist., LV %, ° F. |          |
|------------------------|----------|
| ST/5                   | 648/708  |
| 10/30                  | 737/816  |
| 50                     | 866      |
| 70/90                  | 901/940  |
| 95/EP                  | 957/1001 |

[0079] Various modifications and alterations of this invention will become apparent to those skilled in the art without departing from the scope and spirit of this invention. Other objects and advantages will become apparent to those skilled in the art from a review of the preceding description.

What is claimed is:

1. A process for treating a waxy hydrocarbon feedstock comprising the steps of:

- a) contacting the feedstock with a hydrocracking catalyst in a hydrocracking zone, producing a hydrocracking effluent;
- b) contacting the hydrocracking effluent with an intermediate pore size molecular sieve hydroisomerization catalyst in a hydroisomerization zone, producing a hydroisomerization effluent;
- c) fractionating the hydroisomerization effluent, providing a heavy fraction and a middle distillate fuel; and
- d) dewaxing at least a portion of the heavy fraction to provide a lubricant base oil having a viscosity index of greater than 130, a pour point of less than -15° C., and a viscosity of greater than 3 cSt at 100° C.

2. A process according to claim 1, wherein the lubricant base oil has a viscosity index of greater than 140, a pour point of less than -15° C., and a viscosity of greater than 4 cSt at 100° C.

3. A process according to claim 1, wherein the lubricant base oil has a viscosity index of greater than 150, a pour point of less than -15° C., and a viscosity of greater than 5 cSt at 100° C.

4. A process according to claim 1, wherein the total hydrocracking effluent is contacted with the hydroisomerization catalyst in a hydroisomerization zone.

5. A process according to claim 1, wherein the hydrocracking catalyst and the hydroisomerization catalyst are layered in a single reaction zone in a single reactor.

6. A process according to claim 1, wherein the hydrocracking catalyst and the hydroisomerization catalyst are layered in a single reaction zone in close-coupled series reactors with no product withdrawal or feed inlet between reactors.

7. A process according to claim 1, wherein a portion of the heavy fraction is recycled to the hydrocracking zone.

8. A process according to claim 1, wherein the waxy hydrocarbon feedstock comprises a Fischer Tropsch derived 650° F.+feed.

9. A process according to claim 1, wherein the waxy hydrocarbon feedstock comprises greater than 20 weight % 900° F.+components.

10. A process according to claim 1, wherein the waxy hydrocarbon feedstock comprises greater than 85 wt % 650°

F.+components and wherein less than 60 weight % of the 650° F.+components are converted to 650° F.-products.

11. A process for treating a 650° F.+waxy hydrocarbon feedstock comprising the steps of:

- a) contacting the feedstock with a hydrocracking catalyst in a hydrocracking zone, producing a hydrocracking effluent;
- b) contacting the hydrocracking effluent with an intermediate pore size molecular sieve hydroisomerization catalyst in a hydroisomerization zone, producing a hydroisomerization effluent;
- c) fractionating the hydroisomerization effluent, providing a heavy fraction and a middle distillate fuel; and
- d) dewaxing at least a portion of the heavy fraction to provide a lubricant base oil having a viscosity index of greater than 130, a pour point of less than -15° C., and a viscosity of greater than 3 cSt at 100° C., and wherein less than 60 weight % of the 650° F.+components are converted to 650° F.-products.

12. A process according to claim 11, wherein the lubricant base oil has a viscosity index of greater than 140, a pour point of less than -15° C., and a viscosity of greater than 4 cSt at 100° C.

13. A process according to claim 11, wherein the lubricant base oil has a viscosity index of greater than 150, a pour point of less than -15° C., and a viscosity of greater than 5 cSt at 100° C.

14. A process according to claim 11, wherein the hydrocracking catalyst and the hydroisomerization catalyst are layered in a single reaction zone in a single reactor.

15. A process according to claim 11, wherein the 650° F.+waxy hydrocarbon feedstock is derived from a Fischer Tropsch process.

16. A process according to claim 15, wherein the 650° F.+waxy hydrocarbon feedstock is not hydrotreated prior to hydrocracking.

17. A process according to claim 11, wherein the 650° F.+waxy hydrocarbon feedstock comprises greater than 20 weight % 900° F.+components.

18. A process according to claim 11, wherein the 650° F.+waxy hydrocarbon feedstock comprises greater than 85 wt % 650° F.+components.

19. A process according to claim 11, wherein the hydrocracking catalyst and the hydroisomerization catalyst are layered in a single reaction zone in close-coupled series reactors with no product withdrawal or feed inlet between reactors.

20. A process according to claim 11, wherein a portion of the heavy fraction is recycled to the hydrocracking zone.

21. A process for treating a 650° F.+waxy hydrocarbon feedstock comprising the steps of:

- a) contacting the feedstock with a hydrocracking catalyst in a hydrocracking zone, producing a hydrocracking effluent;

- b) contacting the hydrocracking effluent with an intermediate pore size molecular sieve hydroisomerization catalyst in a hydroisomerization zone, producing a hydroisomerization effluent;

- c) fractionating the hydroisomerization effluent, providing a heavy fraction and a middle distillate fuel; and

- d) dewaxing at least a portion of the heavy fraction to provide a lubricant base oil having a viscosity index of greater than 130, a pour point of less than -15° C., and a viscosity of greater than 4 cSt at 100° C., and wherein the 650° F.+waxy hydrocarbon feedstock comprises greater than 20 weight % 900° F.+components.

22. A process according to claim 21, wherein the 650° F.+waxy hydrocarbon feedstock comprises greater than 40 weight % 900° F.+components.

23. A process according to claim 21, wherein the 650° F.+waxy hydrocarbon feedstock comprises greater than 60 weight % 900° F.+components.

24. A process according to claim 21, wherein the lubricant base oil has a viscosity index of greater than 140, a pour point of less than -15° C., and a viscosity of greater than 4 cSt at 100° C.

25. A process according to claim 21, wherein the lubricant base oil has a viscosity index of greater than 150, a pour point of less than -15° C., and a viscosity of greater than 5 cSt at 100° C.

26. A process according to claim 21, wherein the hydrocracking catalyst and the hydroisomerization catalyst are layered in a single reaction zone in a single reactor.

27. A process according to claim 21, wherein the 650° F.+waxy hydrocarbon feedstock is derived from a Fischer Tropsch process.

28. A process according to claim 21, wherein the hydrocracking catalyst and the hydroisomerization catalyst are layered in a single reaction zone in close-coupled series reactors with no product withdrawal, or feed inlet between reactors.

29. A process according to claim 21, wherein a portion of the heavy fraction is recycled to the hydrocracking zone.

30. A process according to claim 23, wherein the lubricant base oil has a viscosity index of greater than 140, a pour point of less than -15° C., and a viscosity of greater than 4 cSt at 100° C.

31. A process according to claim 23, wherein the lubricant base oil has a viscosity index of greater than 150, a pour point of less than -15° C., and a viscosity of greater than 5 cSt at 100° C.

32. A process according to claim 21, wherein less than 60 weight % of the 650° F.+components of the 650° F.+waxy hydrocarbon feed are converted to 650° F.-products.

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