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A METHOD FOR UPGRADING WAXY FEEDS USING A CATALYST
COMPRISING MIXED POWDERED DEWAXING CATALYST AND
POWDERED ISOMERIZATION CATALYST FORMED INTO A DISCRETE PARTICLE

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates to the catalytic treatment of waxy feeds including slack wax, Fischer-Tropsch wax, waxy raffinates and waxy distillates to produce an upgraded liquid product, such as a lube oil product having improved pour point, viscosity, viscosity index, reduced sulfur and/or nitrogen content as compared to the waxy feeds.

DESCRIPTION OF THE RELATED ART

The isomerization of wax and waxy feeds to liquid products boiling in the lube oil boiling range and catalysts useful in such practice are well known in the literature. Preferred catalysts in general comprise noble Group VIII metals on halogenated refractory metal oxide support, e.g. platinum on fluorided alumina. Other useful catalysts can include noble Group VIII metals on refractory metal oxide support such as silica/alumina which has their acidity controlled by use of dopants such as yttria. Isomerization processes and catalysts used in such processes are disclosed and claimed in numerous patents, see USP 5,059,299; USP 5,158,671; USP 4,906,601; USP 4,959,337; USP 4,929,795; USP 4,900,707; USP 4,937,399; USP 4,919,786; USP 5,182,248; USP 4,943,672; USP 5,200,382; USP 4,992,159, USP 4,923,588, USP 5,294,926, USP 5,254,518. The search for new and different catalysts or catalyst systems which exhibit improved activity, selectivity or longevity, however, is a continuous ongoing exercise.

Catalytic dewaxing is also a process well documented in the literature, see for example, USP 5,135,638, USP 5,246,566, USP 5,282,958, USP 5,037,528, USP 4,975,177, USP 4,919,788, USP 4,9111,821, USP 4,906350, USP 4,696,732, USP 4,610,778, USP 4,717,465,

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USP 4,574,043, USP 4,556,477, USP 4,810,357. Isomerization of linear olefins using zeolites is also addressed in the literature, see, for example, USP 5,321,194, USP 5,237,121.

U.S. Patent 4,141,859 teaches a novel reforming catalyst and process using such catalyst. Zeolites of controlled activity are mixed with reforming catalyst to yield a composite which is then used as part of a catalyst system including an additional component which is a conventional reforming catalyst. The composite comprises up to 25 wt% of a zeolite of controlled acidity and which may be cation exchanged to contain H, Pt, Pd, etc., in combination with not less than 75 wt% of a carrier material containing 0.01 to about 2 wt% platinum either alone or in combination with other metals and from 0.01 to about 3 wt% halide. The carrier material is preferably alumina. The composite can be prepared by pre-milling a conventional reforming catalyst and mixing it with the zeolite and ball milling the mixture then pelleting the mixture to the desired size.

U.S. Patent 4,418,006 teaches a hydrocarbon conversion catalyst system comprising a mixture of a first catalyst containing a noble metal on a refractory inorganic oxide and a second catalyst containing a non-noble metal on a crystalline alumina silicate material dispersed in a high surface area, porous refractory inorganic oxide. The second catalyst can be prepared in any number of ways, one of which involves taking the zeolite which has been cation exchanged and pulverizing it to a powder and physically mixing it with finely divided powder of refractory inorganic oxide and pelleting the mixture and impregnating the pellet with the non-noble metal component. The final system comprising the first catalyst and the second catalyst is then prepared. One method involves reducing the size of each particle, blending the reduced size particles and pelleting the blended mixture.

U.S. Patent 4,302,358 teaches an improved reforming catalyst of improved activity comprising a first component containing a Group VIII noble metal deposited on a solid acidic support and a second component comprising rhenium or compound thereof deposit on a solid

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catalyst support. It is taught that there is a substantial activity increase by thoroughly and intimately blending finely-divided particles of the first and second components to provide a thoroughly-blended composite and subsequently forming the blended composite into larger particles, in contrast to using only a particulate mixture of the first and second catalyst components.

U.S. Patent 4,584,089 teaches a reforming catalyst comprising a two component mixture of thoroughly blended finely divided particles of a first component comprising a Group VIII noble metal on a support having acid catalyst sites and a second component comprising a crystalline borosilicate molecular sieve to produce a thoroughly blended components and forming said composite into particles.

DESCRIPTION OF THE INVENTION

The present invention is directed to a unitized mixed powder pellet catalyst and to a method for upgrading waxy feeds using the unitized mixed powder pellet catalyst. The term "unitized" as used here and in the claims means that each pellet is one made by mixing together powdered molecular sieve dewaxing catalyst(s) with powdered amorphous isomerization catalyst(s) and pelletizing the mixture to produce pellets each of which contain all of the powder components previously recited.

The unitized powder pellet catalyst has been found to produce superior results as compared to using individual catalysts corresponding to the separate components of the mixed powder unitized pellet catalyst.

The unitized catalyst can be prepared by starting with individual finished catalysts, pulverizing and powdering such individual finished catalysts, mixing the powdered materials together to form a homogeneous mass, then compressing/extruding and pelletizing thus producing the unitized pellet catalysts comprising a mixture of the individual, different, and distinct catalyst components.

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Pulverizing and powdering is to a consistency achievable using a mortar and pestle or other such conventional powdering means.

Alternatively individual finished catalysts can be pulverized and powdered then the powdered materials can be mixed together, boehmite or pseudo boehmite powder can be added to the powder mix, the mix can then be compressed/extruded and pelleted and the pellet calcined to covert the boehmite/pseudo-boehmite into alumina resulting in the production of a physically strong, attrition resistant unitized pellet catalyst.

The unitized pellet catalyst can be prepared from a wide variety of individual dewaxing and isomerization catalysts.

The dewaxing catalyst is a 10 member ring unidirectional inorganic oxide molecular sieve having generally oval 1-D pores having a minor axis between about 4.2Å and about 4.8Å and a major axis between about 5.4Å and about 7.0Å as determined by X-ray crystallography. The molecular sieve is preferably impregnated with from 0.1 to 5 wt%, more preferably about 0.1 to 3 wt% of at least one Group VIII metal, preferably a noble Group VIII metal, most preferably platinum or palladium.

While the effective pore size as discussed above is important to the practice of the invention not all intermediate pore size molecular sieves having such effective pore sizes are advantageously usable in the practice of the present invention. Indeed, it is essential that the intermediate pore size molecular sieve catalysts used in the practice of the present invention have a very specific pore shape and size as measured by X-ray crystallography. First, the intracrystalline channels must be parallel and must not be interconnected. Such channels are conventionally referred to as 1-D diffusion types or more shortly as 1-D pores. 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).

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The second essential criterion as mentioned above is that the pores must be generally oval in shape, by which is meant the pores must exhibit two unequal axes, referred to herein as a minor axis and a major axis. The term oval as used herein is not meant to require a specific oval or elliptical shape but rather to refer to the pores exhibiting two unequal axes. Thus, as previously stated the 1-D pores of the catalysts useful in the practice of the present invention must have a minor axis between about 4.2Å and about 4.8Å and a major axis between 5.4Å and about 7.0Å as determined by conventional X-ray crystallography measurements.

Zeolites which are considered to be in this pore range include ZSM-5, ZSM-11, etc. Upon careful examination of the intermediate pore size zeolites, however, it has been found that not all of them are efficient as a catalyst for isomerization of a paraffin-containing feedstock. The intermediate pore size zeolites forming part of the present invention are those which in addition to having the correct pore size are also unidirectional. Such 10 member ring, unidirectional zeolites include ZSM-22, ZSM-23, ZSM-35, ferrierite, ZSM-48, and clinoptilolite and materials isostructural with these as defined Atlas of Zeolite Structure types by S. M. Mier and D. H. Olson., Third Revised Edition 1992.

The most preferred intermediate pore size silicoaluminophosphate molecular sieve for use in the process of the invention is SAPO-11. SAPO-11 comprises a molecular framework of corner-sharing (SiO₂) tetrahedra, (AlO₂) tetrahedra and (PO₂) tetrahedra.

The isomerization catalyst component can be any of the typical isomerization catalyst such as those comprising refractory metal oxide support base (e.g., alumina, silica-alumina, zirconia, titanium, etc.) on which has been deposited a catalytically active metal selected from the group consisting of Group VI B, Group VII B, Group VIII metals and mixtures thereof, preferably Group VIII, more preferably noble Group VIII, most preferably Pt or Pd and optionally including a promoter or dopant such as halogen, phosphorus, boron, yttria, magnesia, etc. preferably halogen, yttria or magnesia, most

preferably fluorine. The catalytically active metals are present in the range 0.1 to 5 wt%, preferably 0.1 to 3 wt%, more preferably 0.1 to 2 wt%, most preferably 0.1 to 1 wt%. The promoters and dopants are used to control the acidity of the isomerization catalyst. Thus, when the isomerization catalyst employs a base material such as alumina, acidity is imparted to the resultant catalyst by addition of a halogen, preferably fluorine. When a halogen is used, preferably fluorine, it is present in an amount in the range 0.1 to 10 wt%, preferably 0.1 to 3 wt%, more preferably 0.1 to 2 wt% most preferably 0.5 to 1.5 wt%. Similarly, if silica-alumina is used as the base material, acidity can be controlled by adjusting the ratio of silica to alumina or by adding a dopant such as yttria or magnesia which reduces the acidity of the silica-alumina base material as taught on U.S. Patent 5,254,518 (Soled, McVicker, Gates, Miseo). As with the dewaxing catalyst composite, one or more isomerization catalysts can be pulverized and powdered, and mixed producing the second component of the unitized mixed pellet catalyst.

The isomerization catalyst can also be the mixture of discrete particle pair catalysts described and claimed in copending application USSN 332,988, filed November 1, 1994 in the names of Ian A. Cody and Alberto Ravella. That catalyst comprises a mixture of discrete particles of two catalysts having acidities in the range 0.3 to 2.3 wherein the catalysts of the catalyst pair have acidities differing by about 0.1 to about 0.9 wherein acidity is determined by the technique of McVicker-Kramer as described in "Hydride Transfer and Olefin Isomerization as Tools to Characterize Liquid and Solid Acids, Acc Chem Res 19, 1986, pg. 78-84. In general one of the catalysts is deemed to be a high acidity catalyst having an acidity as evidenced by having a 3-methylpent-2-ene to 4-methylpent-2-ene ratio in the range 1.1 to 2.3 whereas the other catalyst will be a low acidity catalyst as evidenced by having a 3 methylpent-2-ene to 4 methylpent-2-ene ratio in the range 0.3 to about 1.1.

This method measures the ability of catalytic material to convert 2 methylpent-2-ene into 3 methylpent-2-ene and 4 methylpent-2-ene. More acidic materials will produce more 3 methylpent-2-ene

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(associated with structural rearrangement of a carbon atom on the carbon skeleton). The ratio of 3 methylpent-2-ene to 4 methylpent-2-ene formed at 200°C is a convenient measure of acidity. Isomerization catalyst acidities as determined by the above technique lies in the ratio region in the range of about 0.3 to about 2.5, preferably about 0.5 to about 2.0. Zeolitic dewaxing catalysts have acidities, as determined by the above technique which lie in the ratio region in the range of about 2.5 to 3.0, preferably 2.6 to 2.8.

For a number of catalysts the acidity as determined by the McVicker/Kramer method, i.e., the ability to convert 2 methylpent-2-ene into 3 methylpent-2-ene and 4 methylpent-2-ene at 200°C, 2.4 w/h/w, 1.0 hour on feed wherein acidity is reported in terms of the mole ratio of 3 methylpent-2-ene to 4-methylpent-2-ene, has been correlated to the fluorine content of platinum on fluorided alumina catalyst and to the yttria content of platinum on yttria doped silica/alumina catalysts. This information is reported below.

Acidity of 0.3% Pt on fluorided alumina at different fluorine levels:

<u>F Content (%)</u>	<u>Acidity (McVicker/Kramer)</u>
0.5	0.5
0.75	0.7
1.0	1.5
1.5	2.5
0.83	1.2 (interpolated)

Acidity of 0.3% Pt on yttria doped silica/alumina initially comprising 25 wt% silica:

<u>Yttria Content (%)</u>	<u>Acidity (McVicker/Kramer)</u>
4.0	0.85
9.0	0.7

In practicing the present invention the feed to be isomerized can be any wax or waxy containing feed such as slack wax, which is the

wax recovered from a petroleum hydrocarbon by either solvent or propane dewaxing and can contain entrained oil in an amount varying up to about 50%, preferably 35% oil, more preferably 25% oil, Fischer-Tropsch wax, which is a synthetic wax produced by the catalyzed reaction of CO and H₂. Other waxy feeds such as waxy distillates or waxy raffinates which can contain anywhere from 5 to 95% wax can also be used.

Should the practitioner so desire, the feed can be mildly solvent dewaxed (e.g. to a pour point of about 5°C or 0°C) prior to the upgrading process to recover valuable wax. Solvent dewaxing utilizes typical dewaxing solvents such as C₃-C₆ ketones (e.g., methyl ethyl ketone, methyl isobutyl ketone and mixtures thereof), C₆-C₁₀ aromatic hydrocarbons (e.g., toluene) mixtures of ketones and aromatics (e.g., MEK/toluene), autorefrigerative solvents such as liquified, normally gaseous C₂-C₄ hydrocarbons such as propane, propylene, butane, butylene and mixtures thereof, etc. at filter temperature of -25°C to -30°C. The feed, still containing residual wax is then subjected to the upgrading process.

Waxy feeds secured from natural petroleum sources contain quantities of sulfur and nitrogen compounds which are known to deactivate wax hydroisomerization catalysts. To prevent this deactivation it is preferred that the feed contain no more than 10 ppm sulfur, preferably less than 2 ppm sulfur and no more than 2 ppm nitrogen, preferably less than 1 ppm nitrogen.

To achieve these limits the feed is preferably hydrotreated to reduce the sulfur and nitrogen content.

Hydrotreating can be conducted using any typical hydrotreating catalyst such as Ni/Mo on alumina, Co/Mo on alumina, Co/Ni/Mo on alumina, e.g., KF-840, KF-843, HDN-30, HDN-60, Criteria C-411, etc. Similarly, bulk catalysts comprising Ni/Mn/Mo or Cr/Ni/Mo sulfides as described in U.S. Patent 5,122,258 can be used.

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Hydrotreating is performed at temperatures in the range 280 to 400°C, preferably 340 to 380°C at pressures in the range 500 to 3000 psi, hydrogen treat gas rate in the range of 500 to 5000 SCF/bbl and a flow velocity in the range 0.1 to 5 LHSV, preferably 1 to 2 LHSV.

The upgrading process is practiced at a temperature in the range 300 to 375°C, preferably 330 to 360°C, a pressure in the range 500 to 3000 psi, preferably 1000 to 1500 psi, a hydrogen treat gas rate in the range of 1000 to 10,000 SCF/bbl, preferably 1000 to 3000 SCF/bbl and a flow velocity of 0.1 to 10 LHSV, preferably 0.5 to 2 LHSV.

In both the hydrotreating and upgrading steps, the hydrogen used can be either pure or plant hydrogen (~50-100% H₂).

Following upgrading the total liquid product is fractionated into a lubes cut and fuels cut, the lubes cut being characterized as having a kinematic viscosity of about 2.5 cSt and higher, at 100°C, preferably about 3.0 cSt and higher at 100°C, most preferably about 4 cSt and higher at 100°C.

Preferably it has been found that the total liquid product (TLP) from the upgrading process can be advantageously treated in a second stage at mild conditions using isomerization catalyst or simply noble Group VIII on refractory metal oxide catalyst to reduce PNA and other contaminants in the upgraded product and thus yield an oil of improved daylight stability. The total liquid product is passed over a charge of hydrotreating catalyst, isomerization catalyst or over just noble Gp VIII on e.g. transition alumina. The conditions used include a temperature in the range of about 170-270°C, preferably about 180°C to 220°C, at pressures of about 300 to 2500 psi H₂, preferably 500 to 1500 psi H₂, a hydrogen gas rate of about 500 to 10,000 SCF/bbl, preferably 1000 to 5000 SCF/bbl and a flow velocity of about 0.25 to 10 v/v/hr. preferably about 1-4 v/v/hr. Temperatures at the high end of the range should be employed only when similarly employing pressures at the high end of their recited range.

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Temperatures in excess of those recited may be employed if pressures in excess of 1500 psi are used, but such high pressures may not be practical or economic. A variation of the procedures is covered in USP 5,158,671.

The total liquid product is treated under these conditions in a separate, dedicated unit. It has been found to be unnecessary to fractionate the first stage product prior to this mild second stage treatment. Subjecting the whole product to this mild second stage treatment produces an oil product which upon subsequent fractionation and dewaxing yields a base oil exhibiting a high level of daylight stability and oxidation stability. These base oils can be subjected to subsequent hydrofinishing using conventional catalysts such as KF-840 or HDN-30 (e.g., Co/Mo or Ni/Mo on alumina) at conventional conditions to remove undesirable process impurities to further improve product quality.

The unitized pellet catalyst can contain the individual powdered components which make it up in a broad ratio. Thus, the components can be present in the ratio in the range 1:100 or more to 100 or more: 1, preferably 1:3 to 3:1.

Theta-1 (TON) is a 10-ring, unidirectional silica alumina zeolite for which isotropic framework structures include: ZSM-22, NU-10, ISI-1, and KZ-2. This catalyst possesses excellent catalytic dewaxing potential with high wax content oils and is known to be highly active. The isomerization catalyst 0.3% Pt/1%F/Al₂O₃ is a mildly acidic, highly active isomerization catalyst for producing high VI base oils from slack wax and waxy raffinates. It was reasoned that a mixture of these two catalysts would produce a low wax content (low pour) and high VI base oil.

Example 1

A 600N waxy raffinate was hydrotreated over a C-411 hydro-treating catalyst then stripped to remove H₂S and ammonia.

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C-411 is a commercial hydrotreating catalyst from Criterion. It is a 1/20" trilobe catalyst containing 2.6% wt% Ni and 14.3% wt% Mo on an alumina base. Its physical properties as quoted in the product bulletin are: surface area = 165 m²/g, pore volume = 0.43 cc/g, bulk crush strength = 12.7 kg/cm² and attrition index = 98+ wt%.

The hydrotreated feed following stripping was then sent to units containing either a mixed or stacked bed of discrete particles (25% of a 0.25% Pd loaded TON/75% of a 0.3% Pt/1% F/Al₂O₃ isom catalyst and wherein in the case of the stacked bed the particles of TON were on top of the isom catalyst component) or a bed of unitized mixed powder pellet catalyst made by blending 25% powdered 0.25 Pd TON with 75% powdered 0.3% Pt/1% F-Al₂O₃ and pelleting the resulting blended powder. The TON has a silica alumina ratio of about 60:1. In all three cases the effluent from these units was then sent to a second reactor loaded with 0.3% Pt/1% F-Al₂O₃ and run at 200°C as a stabilization step (in accordance with USP 5,158,671). All reactors were run in up-flow mode.

In all cases the catalysts were crushed and sieved to collect the 7-14 mesh (Tyler) fraction. The units employed 64 g (100 cc) of the 7-14 mesh particles. The catalysts were activated using the following procedure:

1. Hydrogen flow at 0.6 ft³/h (approximately 0.6 SCF/h per 100 cc) at 2.4 MPa (350 psig). No liquid flow.
2. Heat at 8°C/h to 200°C.
3. Hold 24 h.
4. Increase pressure to 4.5 MPa (650 psig) and increase hydrogen rate to 1.6 ft³/h.
5. Increase reactor temperature to 400°C at 8°C/h and hold 400°C for 4 h.

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6. Cool to SOR operating temperature (330°C).
7. Introduce feed (hydrotreated 600NR) at 330°C.

The feed was hydrotreated over C-411 at 370°C 0.7/h LHSV, 1000 psig and 1500 SCF/bbl pure hydrogen treat gas rate. Hydrotreated feed was then introduced into the isomerization unit where the conditions initially were 330°C, 1.0/hr LHSV, 1000 psig total pressure and 2500 SCF/bbl pure hydrogen treat gas rate. The temperature was then increased stepwise to 340°C and 360°C, all other operating conditions being held constant.

The total liquid product from the isomerization unit was fractionated by modified Hivac (Topping) to produce a 370°C cut (lubes cut) which was analyzed for pour point.

The results obtained in this Example are presented in Tables 1A, 1B, and 1C.

The Tables show that the product obtained using the unitized pellet catalyst (having a VI of 106) is of lower pour point (-29 to <-46°C) as compared to the product obtained using a mixed bed of Pd TON pellet catalyst and 0.3% Pb/1%F-AL₂O₃ pellet catalyst (having a VI of 111 and a pour point of -4 to -11°C) or a stacked bed of discrete pellets (VI-110-114 and a pour point of -2 to -7°C) at equivalent reactor temperatures.

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TABLE 1A

CATALYST	600N RAFFINATE	Hydrotreatment	25% Pd TON, 75% ISON CAT	25% Pd TON, 75% ISON CAT	25% Pd TON, 75% ISON Cat
			(Blended Powders & Pelleted)		
Temperature, °C		370	330	340	360
Pressure, PSI		1000	1000	1000	1000
LHSV		0.75	1	1	1
SCF/B		2500	2500	2500	2500
Knockout Liquid					
Yield on Feed			9.55	8.72	8.17
Bottoms Liquid					
Yield on Feed		99	87	83.8	76.6
370°C+ Topped					
Yield on Bottoms	100	95.1	84.4	82.3	71.9
370°C- Fuels	0	4.9	15.6	17.7	28.1
Dry Wax, wt%	23.7	26.9	0	0	0
Overall DWO					
Yield on Feed	76.30	68.82	69.83	65.59	52.38
Topped to 370°C					
(Yes or No)	Y	N(Stripped)	Y	Y	Y
R.I. @ 75°C					
Density @ 15°C	0.8815	0.867			
H.A. Sulfur, wppm	4700	2.2	1.3	< 1	< 2
Antek N, wppm	89	< 1	< 1	< 1	< 2
FLS Sats, wt%	69.57		94.2	92.25	86.62
FLS Aromatics, wt%	30.43		5.8	7.75	13.38
Viscosity, cSt @ 40°C			70.11	66.83	53.61
Viscosity, cSt @ 100°C	10.889	8.065	9.157	8.852	7.642
VI			106	106	106
% C	86.6				
% H	13.4				
Pour Point, °C	52	53	-29	-33	<-46
DSC Wax, wt%	28.9				
Moack Volatility (GCD, wt%)	1.8	9.2	6.2	6.5	9.9
IBP, °C	391	250	342	344	331
5% off.°C	444	350	392	390	373
50% off.°C	506	494	490	488	477
95% off.°C	576	567	564	563	555
FBP, °C	616	605	611	611	603
Topped to 370°C (Y or N)	Y	Y			
H.A. Sulfur, wppm	5800	5.1			
Antek N, wppm	114	<1			
Viscosity, cSt @ 40°C	128,802	76.27			
Viscosity, cSt @ 100°C	12.863	9.658			
VI	91.6	105			
Pour Point, °C	-23	-24			
Moack Volatility (GCD, wt%)	1.9	5.3			
IBP	387	343			
5% off	442	399			
50% off	504	494			
55% off	574	564			
FBP	609	602			

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TABLE 1B

CATALYST	600N RAFFINATE	HYDROTREATMENT	25% Pd TON 75% ISOM CAT	25% Pd TON 75% ISOM CAT	25% Pd TON 75% ISOM CAT
			(<---STACKED BEDS--->)		
Temperature, °C		395	330	340.5	360.4
Pressure, PSI		1000	1000	1000	1000
LHSV		0.75	1	1	1
SCF/B		2500	2500	2500	2500
Knockout Liquid Yield on Feed			0.00	0.85	1.41
Bottoms Liquid Yield on Feed		99	89	83.2	77.8
370°C+ Tapped Yield on Bottoms	100	96.0	85	82.9	73.5
370°C- Fuels	0	5	15	17.1	26.5
Dry Wax, wt%	23.7	26.30			
Overall DWO Yield on Feed	76.30	60.78	71.34	65.04	53.92
Topped to 370°C (Y or N)	Y	N(Stripped)	Y	Y	Y
R.I. @ 75°C		1.4551			
Density @ 15°C	0.8815	0.8668			
H.A. Sulfur wppm	4700	3.2			
Antek N. wppm	89	0.5			
FLS Sats, wt%	69.57	85.6			
FLS Aromatics, wt%	30.43	14.4			
Viscosity, cSt @ 40°C			66.46	62.56	49.39
Viscosity, cSt @ 100°C	10.889	8.003	8.974	8.622	7.464
VI			110	110	114
XC	86.6	85.82			
XH	13.4	14.18			
Pour Point, °C	52		-2	-3	-7
DSC Wax, wt%	28.9	38.3			
Noack Volatility (GCO, wt%)	1.9	9	5.8	6.5	9.6
IBP, °C	391	235	345.6	341.6	329
5% off, °C	444	350.5	394.3	389.2	372.7
50% off, °C	506	494.5	491.1	488.2	478
95% off, °C	576	566.6	564.1	561.9	554.1
IBP, °C	616	605.3	602.4	601.2	592.7
Topped to 370°C (Y or N)	Y	N(Stripped)			
H. A. Sulfur, wppm	5600				
Antek N, wppm	114				
FLS Sats, wt%	63.25				
FLS Aromatics, wt%	36.75				
Viscosity, cSt @ 40°C	128.802	66.803			
Viscosity, cSt @ 100°C	12.863	8.59			
VI	91.6	106			
Pour Point, °C	-23	-23			
Noack Volatility (GCO, wt%)	1.9	9.9			
IBP	387	265.3			
5% off	442	347.4			
50% off	504	490.9			
95% off	574	563.6			
FBP	609	600.5			

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TABLE 1C

CATALYST	600N RAFFINATE	HYDROTREATMENT	25% Pd TON 75%	25% Pd TON 75%	25% Pd TON 75%
			ISOM CAT (<---MIXED PELLETS-->)	ISOM CAT	ISOM CAT
Temperature, °C		370	330	340	360
Premium, PSI		1000	1000	1000	1000
LHSV		0.7	1	1	1
SCF/8		1500	2500	2500	2500
370°C+ Tapped Yield on Bottoms	100		83.9	84.9	73.7
370°C- Fuels	0		16.1	15.1	26.3
Dry Wax, wt%	23.7		7.69	8.50	2.61
Overall DWG Yield on Feed	76.30				
Topped to 370°C (Y or N)	Y	N (Stripped)		Y	Y
R.I. @ 75°C					
Density @ 15°C	0.9815	0.9651			
H. A. Sulfur, wppm	4700	<1			
Antek N, wppm	89	0.5			
FLS Sats, wt%	69.57				
FLS Aromatics, wt%	30.43				
Viscosity, cSt @ 40°C				63	53.7
Viscosity, cSt @ 100°C	10.989	7.797		8.696	7.816
VI				111	111
XC	86.6	85.99			
XH	13.4	14.01			
Pour Point, °C	52	55	-4	-3	-11
DSC Wax, wt%	28.9	37.34			
Noack Volatility (GCO, wt%)	1.9	9.4			
IBP, °C	391	269.4			
5% off, °C	444	352			
50% off, °C	506	491.8			
95% off, °C	576	564.6			
FBP, °C	616	602.3			
Topped to 370°C (Y or N)	Y		Y	Y	Y
H. A. Sulfur, wppm	5600		<3.2	6.2	<3.3
Antek N, wppm	114		<1.6	<1.6	<1.7
FLS Sats, wt%	63.25		93.1	91.64	89.47
FLS Aromatics, wt%	36.75		6.9	8.36	10.53
Viscosity, cSt @ 40°C	128.802		66.3	65.651	53.951
Viscosity, cSt @ 100°C	12.863		8.857	8.813	7.763
VI	91.6		107.1	107.4	108.6
Pour Point, °C	-23		-23	-25	-30
DSC Wax, wt%			17.51	17.05	13.55
NMR H.wt%			13.92	13.81	13.94
Noack Volatility (GCO, wt%)	1.9		6.2	6.4	8.8
IBP	387		346	346	339
5% off	442		391	390	377
50% off	504		489	477	479
95% off	574		561	560	555
FBP	609		600	600	597

Example 2

The same 600N raffinate of Example 1 was subjected to hydro-treatment over a C-411 hydrotreating catalyst then, following stripping to remove H₂S and ammonia was fed to a unit loaded only with palladium loaded TON catalyst pellets (0.25 wt% Pd) operated under a range of conditions.

The conditions of operations and the results of the runs are presented in Table 2 below.

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TABLE 2

CATALYST	600N	C-411	0.25% Pd TON	0.25% Pd TON	0.25% Pd TON
Temperature, °C		370	300.3	330.6	360.5
Pressure, PSI		1000	1000	1000	1000
LHSV		0.74	1.01	1.05	1.01
SCF/B		2368	2460	2342	2369
Knockout Liquid Yield on Feed			3.57	3.89	7.14
Bottoms Liquid Yield on Feed		100.4	92.30	81.6	73.3
370°C+ Topped Yield on Bottoms	100	93.4	83.1	82	81
370°C- Fuels	0	16.6	16.9	18	19
Dry Wax, wt%	23.7	20.1			
Overall DWO Yield on Feed	76.30	74.93	77.01	67.18	59.61
Topped to 370°C (Yes or No)	Y	N(Stripped)	Y	Y	Y
R.I. @ 75°C		1.4545			
Density @ 15°C	0.8815	0.865			
H.A. Sulfur, wppm	4700	1.9	1.1	0.8	0.6
Antek N, wppm	89	0.5	0.5	0.5	0.5
FLS Sats, wt%	69.57	85.46	91.7	90.01	89.71
FLS Aromatics, wt%	30.43	14.54	8.3	9.99	10.29
Viscosity, cSt @ 40°C			68	64.88	63.59
Viscosity, cSt @ 100°C	10.889	7.61	9.188	8.837	8.734
VI			111	110	110
% C	86.6	86.06	85.94	86.09	85.95
% H	13.4	13.92	14.06	13.91	14.05
Pour Point, °C	52	55	-1	-4	-6
DSC Wax, wt%	28.9				
Noack Volatility (GCD, wt%)	1.8	10.9	5.4	5.9	6.2
IBP, °C	391	250.6	344.6	344.4	345.8
5% off, °C	444	332.5	397.1	393.6	390.8
50% off, °C	506	491.9	493.3	489.6	490
95% off, °C	576	565.9	565.9	561.9	563

TABLE 2 (continued)

<u>CATALYST</u>	<u>600N</u>	<u>C-411</u>	<u>0.25% Pd TON</u>	<u>0.25% Pd TON</u>	<u>0.25% Pd TON</u>
FBP, °C	616	604.5	605.2	598.3	601.4
Solvent DWO					
Topped to 370°C (Y or N)	Y	Y			
N.A. Sulfur, wppm	5600				
Antek N, wppm	114				
FLS Sats, wt%	63.25	81.8			
FLS Aromatics, wt%	366.75	18.2			
Viscosity, cSt @ 40°C	128.802	66.39			
Viscosity, cSt @ 100°C	12.863	9.068			
VI	91.6	112			
Pour Point, °C	-23	-8			
Noack Volatility (GCD, wt%)	1.9				
IBP	387				
5% off	442				
50% off	504				
95% off	574				
FBP	609				

Example 3

The same 600N raffinate of Example 1 was subjected to hydro-treatment over a C-411 hydrotreating catalyst, then stripped to remove H_2S and ammonia and the stripped product was fed to a unit containing unitized blended powder pellets catalyst comprising 25% of a 0.25 wt% Pd on ZSM-5/75% of a 0.3 wt% Pt, 1% F/ Al_2O_3 . The ZSM-5 had a silica/alumina ratio of about 64:1. The conditions and results are reported in Table 3 below:

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TABLE 3

<u>CATALYST</u>	<u>FEED TO H07 600N RAFFINATE</u>	<u>FEED TO H06</u>	<u>25% Pd ZSM5 75% RTF-10</u>	<u>25% Pd ZSM5 75% RFT-10 (BLENDED POWDERS)</u>
Temperature, °C		370	270.1	299.8
Pressure, PSI		1000	1000	1000
LHSV		0.73	1	1.02
SCF/B		2438	2497	2447
Knockout Liquid Yield on Feed			6.87	7.60
Bottoms Liquid Yield on Feed		100.5	91.9	83
370°C+ Topped Yield on Bottoms	100	95.6	85.2	84.5
370°C- Fuels	0	4.4	14.8	15.5
Dry Wax, wt%	23.7	24.27		
Overall DWO Yield on Feed	76.30	72.76	78.69	70.49
Topped to 370°C (Yes or No)	Y	N(Stripped)	Y	Y
R.I. @ 75°C		1.4557		
Density @ 25°C	0.8815	0.8682		
H.A. Sulfur, wppm	4700	3.7		
Antek N, wppm	89	0.5		
FLS Sats, wt%	69.57	83.05		
FLS Aromatics, wt%	30.43	16.95		
Viscosity, cSt @ 40°C			82.37	86.75
Viscosity, cSt @ 100°C	10.889	8.325	10.1	10.16
VI			103	97
%C	86.6			
%H	13.4			
Pour Point, °C	52		-3	-19
DSC Wax, wt%	28.9			
Noack Volatility (GCD, wt%)	1.8	8.1	4.5	5.4
IBP, °C	391	262.9	355.4	350.8
5% off, °C	444	363.9	406.3	397.6
50% off, °C	506	495.3	495.4	492.1
95% off, °C	576	566.6	566.3	564
FBP, °C	616	602.5	603.8	599.9

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TABLE 3 (continued)

<u>CATALYST</u>	<u>FEED TO H07 600N RAFFINATE</u>	<u>FEED TO H06</u>	<u>25% Pd ZSM5 75% RFT-10</u>	<u>25% Pd ZSM5 75% RFT-10 (BLENDED POWDERS)</u>
Mass Spec (ASTM D2786-71)				
0 Ring Isoparaffins	30.7	31.3		
1-Ring Cycloparaffins	14.2	21.5		
2-Ring Cycloparaffins	12.8	17		
3-Ring Cycloparaffins	11.2	10.9		
4-Ring Cycloparaffins	9.2	5.3		
5-Ring Cycloparaffins	2.5	1.7		
6-Ring Cycloparaffins	2.7	0.6		
Monoaromatics	16.8	11.8		
DWO Code #	DNZ-000428	DNZ-001176		
Topped to 370°C (Y or N)	Y	Y		
H.A. Sulfur, uppm	5600	6.5		
Antek N, uppm	114	0.5		
FLS Sats, wt%	63.25	79.54		
FLS Aromatics, wt%	36.75	20.46		
Viscosity, cSt @ 40°C	128.802	79.49		
Viscosity, cSt @ 100°C	12.863	9.883		
VI	91.6	104		
Pour Point	-23	-18		
DSC Wax, wt%				
NMR H, wt%				
Noack Volatility (GCD, wt%)	1.9	4.7		
IBP	387	347.2		
5% off	442	404.8		
50% off	504	494.2		
95% off	574	564		
FBP	609	598.2		

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TABLE 3 (continued)

<u>CATALYST</u>	<u>FEED TO H07</u> <u>600N</u> <u>RAFFINATE</u>	<u>FEED</u> <u>TO H06</u>	<u>25% Pd ZSM5</u> <u>75% RFT-10</u>	<u>25% Pd ZSM5</u> <u>75% RFT-10</u> <u>(BLENDED</u> <u>POWDERS)</u>
Mass Spec (ASTM D2786-71)				
0 Ring Isoparaffins	20.5	21.2		
1-Ring Cycloparaffins	15.3	22.3		
2-Ring Cycloparaffins	15	19.8		
3-Ring Cycloparaffins	13.2	12.8		
4-Ring Cycloparaffins	10.6	6.7		
5-Ring Cycloparaffins	2.5	2.8		
6-Ring Cycloparaffins	2.7	1.4		
Monoaromatics	20.2	13.1		

From this it is seen that not all zeolites are appropriate for use in the present invention. The mixed powder pellet catalyst containing 25 wt% Pd/ZSM-5 produced a product of only 97 VI with a pour point of -19°C on a feed which if simply solvent dewaxed would have a VI of 104 and a pour point of -18 . This is to be compared with the product produced using a mixed powder pellet catalyst containing 25 wt% Pd-TON (Example 1) which had a VI of 106 and a pour point of -46°C (on a feed which if simply solvent dewaxed would have a VI of 105 and a pour of -24°C) or even with the product produced in Example 2 using only Pd/TON (no isom catalyst component) which had a VI of 110 and a pour point of -6 on a feed which if simply solvent dewaxed would have a VI of 112 and a pour point of -8°C . ZSM-5 is an oval pore zeolite but is not unidirectional. This is to be compared with the structure of Theta-1 (TON or ZSM-22) which is a 10 member ring-unidirectional pore material wherein the pores are oval.

Example 4

A 250N raffinate was hydrotreated over a C-411 hydrotreating catalyst, stripped to remove H_2S and ammonia then fed to units containing either unitized mixed powder pellet catalyst comprising 25 wt% of 0.25% Pd-ZSM-5/75 wt% of a 0.3% Pt/1.0% F/ Al_2O_3 catalyst or a 0.25% Pd on TON catalyst. The ZSM-5 had a silica/alumina ratio of about 64:1. The conditions used and the results obtained are present in Table 4, below.

TABLE 4

	Feed 250N RAFFINATE	C-411	0.25X Pd TON	0.25X Pd TON	0.25X Pd TON	25X Pd ZSM5 75X ISOM CAT	25X PD ZSM5 75X ISOM CAT	25X Pd ZSM5 75X ISOM CAT
						<-- BLENDED POWDERS/PELLETED -->		
Temperature, °C		370	300.5	330.4	360.3	300.3	280.2	269.2
Pressure, PSI		1000	1000	1000	1000	1000	1000	1000
LHSV		0.73	1	1.01	1.06	1.01	1.04	1.01
SCF/B		3149	2525	2491	2331	2461	2380	2412
Knockout Liquid Yield on Feed			5.84	5.54	7.81	13.32	9.57	6.05
Bottoms Liquid Yield on Feed		96.7	91.4	83.6	68.7	74.8	80.3	85.4
370°C+ Topped Yield on Bottoms	100	92.3	79.9	79.2	77.7	76.6	77.9	79.3
370°C- Fuels	0	7.7	20.1	20.8	22.3	23.2	22.1	20.7
Dry Wax, wt%	17.7	20.5						
Overall DMO Yield on Feed	82.30	70.96	70.62	64.03	51.62	55.55	60.49	65.49
Topped to 370°C (Yes or No)	Y	N(Stripped)	Y	Y	Y	Y	Y	Y
R.I. @ 75°C	1.4598							

TABLE 4 (continued)

	Feed 250N RAFFINATE	C-411	0.25X Pd TON	0.25X Pd TON	0.25X Pd TON	25X Pd ZSM5 75X ISOM CAT	25X PD ZSM5 75X ISOM CAT	25X Pd ZSM5 75X ISOM CAT
						<-- BLENDED POWDERS/PELLETED -->		
Density @ 15°C	0.8754							
H.A. Sulfur, wppm	7200	1.6	0.6	0.7	0.5	0.5	0.5	0.5
Antek N, wppm	44	0.5	0.5	0.5	0.5	0.5	0.5	0.5
FLS Sats, wt%	71.8	87.8	87.6	89.34	91.54	93.48	92.55	91.91
FLS Aromatics, wt%	26.2	12.2	12.4	10.66	8.46	6.52	7.45	8.09
Viscosity, cSt @ 40°C			37.48	37.66	36.53	44.97	43.72	41.99
Viscosity, cSt @ 100°C	6.855	5.091	6.176	6.154	6.024	6.563	6.575	6.473
VI			112	110	109	95	101	104
% C	86.28	85.82	86.06		85.82			
% H	13.72	14.18	13.94		14.18			
Pour Point, °C	38		-9	-14	-16	-49	-24	-17
DSC Max, wt%	32.5					7.6	14.23	
Noack Volatility (GCD, wt%)	6.2	17.2	10.5	10.5	11.4		10.6	10.2

TABLE 4 (continued)

	Feed 250N RAFFINATE	C-411	0.25% Pd TON	0.25% Pd TON	0.25% Pd TON	25% Pd ZSM5 75% ISOM CAT	25% PD ZSM5 75% ISOM CAT	25% Pd ZSM5 75% ISOM CAT
						<-- BLENDED POWDERS/PELLETED -->		
IBP, °C		243.1	335.4	335.4	330.3	330.2	336.1	337.2
5% off, °C		311.9	378.7	378.9	373.9	371.2	378.3	380.7
50% off, °C		449.3	451.7	452.3	450.7	448.4	451.4	452.2
95% off, °C		509.8	510	510.6	509.3	508.1	509.5	509.8
FBP, °C		545.5	541.4	542.4	541.3	539.8	540	540.4
DWD Code #	GGM-000513	DNZ-001153						
Topped to 370°C (Yes or No)	Y	Y						
H.A. Sulfur, wppm	8500							
Antek N, wppm	47							
FLS Sats, wt%	67.38	84.7						
FLS Aromatics, wt%	32.62	15.3						
Viscosity, cSt @ 40°C	50.38	35.28						
Viscosity, cSt @ 100°C	7.154	5.987						

TABLE 4 (continued)

	Feed 250N RAFFINATE	C-411	0.25% Pd TON	0.25% Pd TON	0.25% Pd TON	25% Pd ZSM5 75% ISOM CAT	25% PD ZSM5 75% ISOM CAT	25% Pd ZSM5 75% ISOM CAT
						<-- BLENDED POWDERS/PELLETED -->		
VI	96	114						
Pour Point, °C	-16	-17						
DSC Wax, wt%								
NMR H, wt%								
Noack Volatility (GCD, wt%)		10.8						
IBP		329.6						
5% off		376.7						
50% off		451.9						
95% off	509.9							
FBP	541.9							

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From this it is seen that using a unitized mixed powder pellet catalyst containing 25 wt% of a zeolite of the kind ZSM-5 produces a product of lower VI (VI#104 at equivalent pour point) as compared to the product obtained by practicing either solvent dewaxing (VI 114) or treatment using only 0.25% Pd-TON (VI#109). There is no advantage to using a mixed powder pellet catalyst wherein one of the components is of the type represented by ZSM-5, i.e. an oval pore zeolite which is not unidirectional.

**CLAIMS:**

1. A method for upgrading waxy feeds said method comprising contacting the waxy feed under upgrading conditions of elevated temperature, and pressure in the presence of hydrogen with a catalyst comprising a unitized powder pellet catalyst made by mixing powdered molecular sieve dewaxing catalyst comprising a 10 member ring unidirectional pore inorganic oxide molecular sieve with a powdered isomerization catalyst, mixing the powdered materials together to form a homogeneous mass, compressing/extruding the mass and pelleting the extruded/compressed mass.

2. The method of claim 1 wherein the powdered molecular sieve and the powdered isomerization catalyst are mixed together and boehmite or pseudo boehmite is added to the mixture, the mixture is compressed/extruded and pelleted and the pellets calcined to convert the boehmite/pseudo boehmite into alumina producing the catalyst pellets.

3. The method of claim 1 or 2 wherein the 10 member ring unidirectional pore inorganic oxide molecular sieve has generally oval 1-D pores having a minor axis between about 4.2 Å and about 4.8 Å and a major axis between about 5.4 Å and about 7.0 Å as determined by X-ray crystallography.

4. The method of claim 1 or 2 wherein the powdered molecular sieve dewaxing catalyst and the powdered isomerization catalyst are combined in a ratio in the range 1:100 or more to 100 or more :1.

5. The method of claim 3 wherein the inorganic oxide molecular sieve contains from 0.1 to 5 wt% of at least one Group VIII metal.

6. The method of claim 5 wherein the inorganic oxide molecular sieve contains a Group VIII metal selected from platinum and palladium.



7. The method of claim 1 or 2 wherein the inorganic oxide molecular sieve is selected from ZSM-22, ZSM-23, ZSM-35, ferrierite, ZSM-48, clinoptilolite and materials isostructural therewith, and SAPO-11.
8. The method of claim 5 wherein the inorganic oxide molecular sieve is selected from ZSM-22, ZSM-23, ZSM-35, ferrierite, ZSM-48, clinoptilolite and materials isostructural therewith, and SAPO-11.
9. The method of claim 1 or 2 wherein the isomerization catalyst comprises a catalytically active metal selected from the group consisting of Group VIB, Group VIIB, Group VIII metals and mixtures thereof on a refractory metal oxide support base.
10. The method of claim 9 wherein the refractory metal oxide support base further includes a dopant selected from halogen, phosphorus boron, yttria, magnesia.
11. The method of claim 10 wherein when the refractory metal oxide support base is alumina the dopant is a halogen.
12. The method of claim 11 wherein the dopant is fluorine.
13. The method of claim 10 wherein when the refractory metal oxide support base is silica-alumina the dopant is yttria or magnesia.
14. The method of claim 1 or 2 wherein the waxy feed is hydrotreated prior to being upgraded.
15. The method of claim 14 wherein hydrotreating is performed at temperatures in the range 280 to 400°C, pressures in the range 500 to 3000 psi, hydrogen treat gas rate in the range 500 to 5000 SCF/bbl and a flow velocity in the range 0.1 to 5 LHSV.
16. The method of claim 1 or 2 wherein the upgrading conditions used include a temperature in the range 300 to 375°C, a pressure



in the range 500 to 3000 psi, a hydrogen treat gas rate in the range 1000 to 10,000 SCF/bbl and a flow velocity in the range 0.1 to 10 LHSV.

17. A unitized mixed power pellet upgrading catalyst made by mixing powdered molecular sieve dewaxing catalyst comprising a 10 member ring unidirectional pore inorganic oxide molecular sieve with a powdered isomerization catalyst, mixing the powdered material together to form a homogeneous mass, compressing/extruding the mass and pelletizing the compressed/extruded mass.

18. The catalyst of claim 17 wherein the powdered molecular sieve and the powdered isomerization catalyst are mixed together and boehmite or pseudo boehmite is added to the mixture, the mixture is compressed/extruded and pelleted and calcined to convert the boehmite/pseudo boehmite into alumina producing the unitized catalyst pellets.

19. The catalyst of claim 17 or 18 wherein the 10 number ring unidirectional pore inorganic oxide molecular sieve has generally oval 1-D pores having a minor axis between about 4.2 Å and about 4.8 Å and a major axis between about 5.4 Å and about 7.0 Å as determined by X-ray crystallography.

20. The catalyst of claim 16 or 17 wherein the powdered molecular sieve dewaxing catalyst and the powdered isomerization catalyst are combined in a ratio in the range 1:100 or more to 100 or more :1.