PROCESS FOR MAKING A LUBE BASESTOCK

FIELD OF THE INVENTION

This invention relates to the hydroisomerization of waxy feeds including slack wax, slack wax isomerate, Fischer-Tropsch wax, Fischer-Tropsch hydroisomerate waxy raffinates, and waxy distillates to produce a lube oil basestock or blending stock. More specifically, this invention relates to the conversion of a waxy feed using a mixed catalyst having a preselected acidity capable of promoting the formation of a basestock having a predetermined (VI) within a range of VI's.

BACKGROUND OF THE INVENTION

The performance criteria for lubricants such as those used in automatic transmission fluids and passenger car engine oils has become increasingly more severe with users requiring basestock that provide better wear protection, improved volatility and low temperature properties.

Waxy feeds can be converted to liquid products using well known catalytic dewaxing catalysts; however, in these instances the selective cracking of paraffins typically results in a loss of viscosity (VI) which is undesirable.

In contrast, isomerization of waxy feeds using molecular sieve based catalyst that have linear 1D pore structures produces lube basestocks without loss in VI. While these catalysts offer benefits over those used in catalytic dewaxing, there nonetheless remains a need for improved catalysts for

converting waxy feeds to lube basestocks that can be tailored to produce basestocks having a predetermined quality and yield.

SUMMARY OF THE INVENTION

This invention relates to a method for hydroisomerizing a waxy feed to produce improved yield of a lube basestock which comprises: contacting the waxy feed under hydroisomerization conditions with a catalyst comprising a unitized mixed powdered pellet catalyst having (1) a first dewaxing component selected from 8, 10 and 12 ring molecular sieves and mixtures thereof; (2) a second isomerization component which is an amorphous inorganic oxide; and (3) at least one of a Group VIB and a Group VIII metal hydrogenation component, wherein the first and second components are present in a ratio such that when evaluated in the conversion of methyl cyclohexane at 320°C to 1,1-dimethylcyclopentane, 1,2-dimethylcyclopentane, 1,3-dimethylcyclopentane and ethylcyclopentane, the catalyst will provide a trans-1,2-/trans-1,3-dimethyl-cyclopentane ratio of less than 1 and a selectivity to ethylcyclopentane, at 10% conversion, of at least about 50%. The invention also relates to a method for hydroisomerizing a waxy feed to produce improved viscosity index (VI) of a lube basestock by the foregoing method wherein the ratio is at least 1.

This and other embodiments of the invention will be discussed below.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a schematic drawing showing the conversion of methylcyclohexane to various cyclopentane compounds at 320°C.

DESCRIPTION OF THE INVENTION

The feed suitable in the practice of the present invention includes waxy hydrocarbon oils such as slack wax, slack wax isomerate, Fischer-Tropsch wax, Fischer-Tropsch isomerate waxy raffinates and waxy distillates. Typically, such feeds will have wax contents of 15% or more. The preferred feed will have a nitrogen and sulfur content each below about 20 wppm or more. The preferred feed will have a nitrogen and sulfur content each below about 20 wppm. Indeed, if the feed contains higher amounts of sulfur and nitrogen, the feed can be first subjected to hydrotreating under typical hydrotreating conditions to reduce the sulfur and nitrogen contents. Any of the conventional hydrotreating catalysts can be employed like Ni/Mo on alumina, Ni/W on alumina Co/Mo on alumina. In other words any of the Group VIB to Group VIII (The groups referred to here and hereinafter are those metals of the Periodic Table of Elements; Sargent-Welch Scientific Co.) on metal oxide refractory supports may be employed. Commercial examples of such are identified as HDN-30 and KF-840.

Hydrotreating is conducted so as to lower the sulfur and nitrogen contents to levels of 20 wppm or less nitrogen or 20 wppm or less sulfur especially 10 ppm less nitrogen and 10 ppm or less sulfur and most preferably to levels below 5 ppm for nitrogen and 5 ppm or less for sulfur.

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.

Hydrotreating is performed at temperatures in the range 280°C to 400°C, preferably 340°C 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 hydrotreated waxy oil is stripped to remove ammonia and H_2S and then is subjected to the hydroisomerization process of the present invention.

The catalyst employed in the hydroisomerization of waxy feeds in accordance with the present invention is a unitized mixed powdered pellet catalyst. The term "unitized" as used here and in the claims means that each pellet is one made by mixing together a powdered first component with a powdered second component and pelletizing the mixture to produce pellets each of which contain all of the powder components previously recited.

The unitized catalyst can be prepared by starting with individual finished powdered components pulverizing and powdering such individual finished components, mixing the powdered materials together to form a

homogeneous mass, then compressing/extruding and pelleting thus producing the unitized pellet catalysts. Pulverizing and powdering is to a consistency achievable using a ball mill or other such conventional powdering means to a particle size less than 100 microns.

The first component is a catalytic dewaxing component including crystalline 8, 10 and 12 ring molecular sieves. Crystalline molecular sieves include metallo-, e.g., alumino silicates, alumino phosphates and silicoaluminophosphates. Examples of crystalline alumino silicates include zeolites such as erionite, chabazite, ZSM-5, ZSM-11, ZSM-12, Theta-1 (ZSM-22), ZSM-23, ZSM-35, ZSM-48 natural and synthetic ferrierites, ZSM-57, beta mordenite and offretite. Examples of crystalline alumino- and silicoalumino-phosphates include SAPO-11, SAPO-41, SAPO-31, MAPO-11 and MAPO-31. Preferred include ZSM-5, ZSM-22, ZSM-23, ferrierites, and SAPO-11.

The second isomerization component can be any of the typical isomerization catalyst such as those comprising amorphous refractory metal oxide support base (e.g., alumina, silica, zirconia, titania, silica-magnesia, silica-alumina, etc.) on which has been preferably deposited a catalytically active metal selected from 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 yttria, rare earth oxides, from, e.g., La, Ce, etc., boria, magnesia, etc. 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 an acidic material such as silica-alumina, acidity of the resultant catalyst is reduced by addition of a basic material such as

yttria, rare earth oxides, from e.g., La, Ce, etc., boria or magnesia or by controlling the ratio of silica:alumina in the silica-alumina.

The metal hydrogenation component can be deposited on either the first dewaxing component, the second isomerization component or preferably on both the first and second components. The metal is selected from at least one of Group VIB and Group VIII, preferably Group VIII, more preferably Pt or Pd. The amount of metal can range from 0.1 to 30 wt%, based on catalyst. If the metal is Pt or Pd, the preferred amount is from 0.1 to 5 wt%, based on catalyst. In order to maximize catalyst utilization, it is preferred that the metal dispersion be at least 0.3 (on a scale where 100% metal dispersion is 1.0) if the metal is only on one component. If the metal is on both components, then it is preferred that the metal dispersion (D) times the metal concentration (C) (i.e., D x C) on one of the components be at least 0.08.

The first and second components are combined in a ratio sufficient to promote wax isomerization and naphthene destruction without substantial decrease in VI. The zeolite to amorphous inorganic oxide ratios for catalysts according to the invention range from about 1:1 to 1:20 by weight, subject to the MCH test described below.

One technique for determining the proper ratio of first and second components in the catalyst is based on an evaluation of the combined components containing about 0.5 wt% Pt in converting methylcyclohexane (MCH) to various cyclopentane compounds. Catalyst that at 320°C provide a ratio of trans 1,2-dimethylcyclopentane to trans-1,3-dimethylcyclopentane (trans-1,2/trans-1,3 DMCP) in the range of less than 1 have been found to

promote maximum yields of basestocks whereas ratios in the range of greater than about 1 promote maximum VI.

The second factor is when the catalyst, impregnated with about 0.5 wt% Pt and evaluated in converting methylcyclohexane to various cyclopentane compounds at 10% conversion, exhibits a selectivity for ethylcyclopentane (ECP) formation above at least 50%.

This technique is further explained as follows. The reaction of MCH over the catalyst to various cyclopentane products is shown in Figure 1. As indicated in Figure 1, the products of MCH decomposition include ethyl-cyclopentane, cis- and trans-1,2-dimethylcyclopentane, cis- and trans-1,3-dimethylcyclopentane and 1,1-dimethylcyclopentane. This technique, also known as the MCH test is used to define relative acid site concentration, strengths and active site constraint for the catalysts according to the invention.

The key factors are summarized as follows: (1) total conversion of MCH for a given catalyst weight at 320°C is an indication of the relative number of acid sites; (2) selectivity to ECP, at 10% conversion, is a measure of the relative acid strength wherein high ECP selectivity values indicates low acid strength and low ECP selectivity values indicates high acid strength; and (3) the ratio of trans-1,2-DCMP to trans-1,3-DCMP correlates with the constraint at the catalyst active site wherein a high ratio (>1) indicates little or no physical constraint at the active site and a low ratio (<1) indicates a physical constraint at the active site.

In the present process, to produce a catalyst that will give high yield, the ratio of trans-1,2-DCMP to trans-1,3-DCMP is adjusted to less than

about 1 predominantly by controlling both the number and strength of the amorphous isomerization component. It is preferred to use lower acid strength amorphous components such as alumina.

Conversely, a catalyst that will maximize VI is produced by increasing the acid strength of the amorphous phase. In this case it is preferred to use higher acid strength amorphous components such as silica-aluminas or modified silica-aluminas. Another way of making such a catalyst is by changing the ratio of the microporous component to the amorphous component such that the unitized catalyst has a trans-1,2/trans-1,3 DMCP ratio of >1.

The hydroisomerization process utilizing the catalyst of the present invention is conducted at temperatures between about 200°C to 400°C, preferably 250°C to 380°C, and most preferably 300°C to 350°C at hydrogen partial pressures between about 350 to 5,000 psig (2.41 to 34.6 mPa), preferably 1,000 to 2500 psig (7.0 to 17.2 mPa), a hydrogen gas treat ratio of 500 to 10,000 SCF H_2/bbl (89 to 1780 m^3/m^3), preferably 2,000 to 5,000 SCF H_2/bbl (356 to 890 m^3/m^3) and a LHSV of 0.1 to 10 v/v/hr, preferably 0.5 to 5 v/v/hr, and more preferably 1 to 2 v/v/hr.

In an alternate embodiment of the present invention the waxy feed is first subject to solvent dewaxing to a pour point of the order of +10°C or lower.

The dewaxing solvent used may include the C_3-C_6 ketones such as methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), mixtures of MEK and MIBK, aromatic hydrocarbons like toluene, mixtures of ketones and aromatics like MEK/toluene, ethers such as methyl t-butyl ethers and mixtures of

same with ketones or aromatics. Similarly, liquefied, normally gaseous hydrocarbons like propane, propylene, butane, butylene, and combinations thereof may be used as the solvent. Preferably the solvent employed will be an equal volume mixture of methyl ethyl ketone and methyl isobutyl ketone. Typically the isomerate to solvent ratio will range between 1 to 10 and preferably will be about 1:3. The dewaxed feed is then subjected to hydroisomerizing as described hereinabove.

The present invention is demonstrated below in the non-limiting examples.

EXAMPLES

Example 1

This example illustrates the yield-VI trade-off on a hydrocracker distillate (Feed A) for catalysts with different degrees of acidity in the amorphous component. The physical properties of the hydrocracker distillate (Feed A) are shown in Table 1.

Table 1: Properties of Hydrocracker Distillate Feed A

Viscosity, cSt at 100°C,	5.19
Viscosity, cSt at 135°C,	2.994
VI	150
Wax Content, wt%	33.5
Boiling Range, (5/95%) °C	235-533

The catalyst in Table 2 (column B) was made by combining the zeolite theta-1 (TON) in the powder form with alumina (BET Surface Area 190 m^2/m^3) in the powder form followed by intimate mixing so as to form a

homogeneous powdered mixture and then forming into catalyst pellets by pressing in a die and sizing to the required mesh size. Both the TON and the alumina had been loaded with palladium in the powdered form using aqueous palladium tetraamine dinitrate (at pH = 10) and palladium dichloride respectively before being intermixed.

The catalyst in Table 2 (column C) was made by combining the zeolite TON with silica-alumina (Si-Al) using the same technique as used in column A to produce a homogeneous powdered catalyst before forming into pellets. In this case, the palladium was loaded (as palladium tetraamine dinitrate) on to the finished unitized catalyst by incipient wetness.

Table 2 shows a comparison of activity and selectivity of these two catalysts for hydrodewaxing versus solvent dewaxing (column A). The acidity differences of each catalyst component and the corresponding finished unitized catalysts is also shown using the reaction of methylcyclohexane at 320°C. The table clearly shows the higher acidity (greater number and acid strength) silica-alumina catalyst (column C) gives lower yield but much higher VI compared with the very low acidity associated with alumina (column B) which results in high yield but a debit in VI.

TABLE 2
Feed: Hydrocracker Distillate A

		A	B	C
CATALYST		Solvent Dewaxing	0.25 wt% Pd TON / 0.25 wt% Pd Alumina	0.3 wt% Pd TON / 0.3 wt% Silica-Alumina
CONDITIONS				
Temperature, °C			340	329
Pressure, psig			1000	1000
v/v/hour			1.0	1.0
T G Rate, scf/bbl			2500	2500
PRODUCT PROPERTIES				
Yield, 370°C		50	65	40
VI		117	119	122
Viscosity at 100°C, cSt		5.45	5.45	4.81
Viscosity at 40°C, cSt		30.23	29.97	24.09
Pour Point, °C		- 33	- 37	- 38
MCH (microporous) (0.5 wt% Pt on TON)	Conversion at 320°C		19.2	19.2
	ECP		61	61
	trans-1,2/trans-1,3 DMCP		0.16	0.16
MCH (amorphous support)	Conversion at 320°C		0.1	> 8
	ECP		n/a	50
	trans-1,2/trans-1,3 DMCP		< 1	> 1
MCH (unitized catalyst)	Conversion at 320°C		7.1	14.4
	ECP		57	59
	trans-1,2/trans-1,3 DMCP		0.15	1.48

Example 2

This example further illustrates the yield-VI trade off and shows a comparison of activity and selectivity of two catalysts for hydrodewaxing a hydrocraker distillate (Feed B) versus solvent dewaxing. The physical properties of the hydrocracker distillate (Feed B) are shown in Table 3.

Table 3: Properties of Hydrocracker Distillate Feed B

Viscosity, cSt at 100°C,	3.99
Viscosity, cSt at 135°C,	2.366
VI	127
Wax Content, wt%	22.4
Boiling Range, (5/95%), °C	325-475

TABLE 4
Feed: Hydrocracker Distillate B

		A	B	C
CATALYST		Solvent Dewaxing	Pd TON (25) / Pt Al_2O_3 (75)	Pd TON (25) / Si-Al (75)
Average Reactor Temperature, °C		--	314	329
Pressure, psig		--	1000	1000
v/v/hr		--	1.0	1.0
TG Rate, scf/bbl		--	2500	2500
PRODUCT PROPERTIES				
Yield, 350°C+		75	80	74
VI		110	113	117
Viscosity at 100°C, cSt		3.94	3.93	3.75
Viscosity at 40°c, cSt		--	--	--
Pour Point, °C		- 21	- 23	- 18
MCH (microporous) (0.5 wt% Pt on TON)	Conversion at 320°C		19.2	19.2
	ECP		61	61
	trans-1,2/trans-1,3 DMCP		0.16	0.16
MCH (amorphous support)	Conversion at 320°C	n/a	0.1	< 8
	ECP	n/a	n/a	50
	trans-1,2/trans-1,3 DMCP	n/a	< 1	> 1
MCH (unitized catalyst)	Conversion at 320°C	n/a	7.1	14.4
	ECP	n/a	57	59
	trans-1,2/trans-1,3 DMCP	n/a	0.15	1.48

The methods of making two of these catalysts (columns B and C) were described in Example 1.

Columns B and C in Table 4 allow a comparison of the yields and VI's obtained by both catalysts. Again the least acidic catalyst (column B) exhibits higher yields with lower VI's compared with the higher acidic catalyst (column C).

Example 3

This example further illustrates the yield-VI trade and shows a comparison of activity and selectivity of two catalysts for hydroisomerization a hydrocraker distillate (Feed B) versus solvent dewaxing. This example illustrates that by changing the relative amounts of microporous component to amorphous component the overall acidity of the unitized catalyst an be tailored to maximize yield or VI.

Table 5 compares two unitized catalysts both of which have been made by combining the powdered ZSM-5 (Si/Al ratio 110) with the powdered amorphous component in different ratios and then loading platinum by incipient wetness using platinum tetraamine dichloride. Table 5 shows a comparison of activity and selectivity for these catalysts for dewaxing hydrocracker distillate B, the physical properties of which are shown in Table 3, with solvent dewaxing. The catalyst in column B which has a trans-1,2/trans-1,3 DMCP ratio of less than 1 shows higher yield but lower VI than the catalyst in column C which has a trans-1,2/trans-1,3 DMCP ratio greater than 1.

TABLE 5
Feed: Hydrocracker Distillate B

CATALYST (WT%)		A Solvent Dewaxing	B Pt ZSM-5 (50) / Silica-Alumina (50)		C Pt ZSM-5 (10) / Silica-Alumina (90)	
CONDITIONS						
Average Reactor Temperature, °C			314	329	329	339
Pressure, psig		--	1000		1000	
v/v/hr		--	1.0		1.0	
TG Rate, scf/bbl		--	2500		2500	
PRODUCT PROPERTIES						
Yield, 350°C+		75	65	50	55	45
VI		110	106	102	112	109
Viscosity at 100°C, cSt		3.94	4.1	4.05	3.83	3.81
Viscosity at 40°c, cSt		18.56	19.528	19.84	17.33	17.306
Pour Point, °C		-21	-23	-43	-20	-36
MCH (microporous) (0.5 wt% Pt on ZSM-5)	Conversion at 320°C		21.1		21.1	
	ECP		52		52	
	trans-1,2/trans-1,3 DMCP		0.02		0.02	
MCH (amorphous support)	Conversion at 320°C		12.1		12.1	
	ECP		48		48	
	trans-1,2/trans-1,3 DMCP		2.11		2.11	
MCH (unitized catalyst)	Conversion at 320°C	n/a	10.6		12	
	ECP	n/a	47		50	
	trans-1,2/trans-1,3 DMCP	n/a	0.82		1.8	

Example 4

This example illustrates that good hydrogenation metal dispersion is required for maximum catalyst conversion. However, the metal in a mixed powdered catalyst can be dispersed on the microporous component or on the amorphous component.

The catalysts in Table 6 were made by combining the zeolite theta-1 (TON) in the powder form with alumina (BET Surface Area $190m^2/m^3$) in the powder form followed by intimate mixing so as to form a homogeneous powdered mixture and then forming into catalyst pellets by pressing in a die and sizing to the required mesh size.

The TON in the catalyst in column A had been loaded with platinum tetramine dinitrate before being intermixed with alumina.

The TON in the catalyst in column B had been loaded with palladium in the powdered form using aqueous palladium tetraamine dinitrate (at pH=10) before being intermixed with alumina.

The TON in the catalyst in column C had been loaded with palladium in the powdered form using aqueous tetramine dinitrate (at pH=10) before being intermixed with platinum loaded (as platinum dichloride) alumina.

The catalyst in column D was made as described in Example 1.

Table 6, columns A and B, compares the activity of two TON zeolite/alumina mixed powder catalysts in which the noble metal has been

loaded only on the TON zeolite component. The Pd TON/alumina catalyst (column B), which has 12% metal dispersion, is shown to have much lower activity for pour point reduction than the Pt TON/alumina catalyst (column A) which has 65% metal dispersion.

Loading additional Pt or Pd on the alumina component (Column C, and Column D, respectively) improves the activity of the catalyst to the level of that observed in Column A.

TABLE 6

Feed: Hydrocracker Distillate, Feed B

	A			B			C			D		
Catalyst Components	0.46 wt% Pt TON (25) / Al_2O_3 (75)			0.25 wt% Pd TON (25) / Al_2O_3 (75)			0.25 wt% Pt TON / 0.46 wt% Pt Al_2O_3			0.25 wt% Pd TON / 0.25 wt% Pd Al_2O_3		
Metal Dispersion on Components	0.65 / --			0.12 / --			0.12 / 0.94			0.12 / 0.41		
Average Reactor Temperature, °C	Pour Point, °C	VI	Yield on Feed, wt%	Pour Point, °C	VI	Yield on Feed, wt%	Pour Point, °C	VI	Yield on Feed, wt%	Pour Point, °C	VI	Yield on Feed, wt%
315	- 4	117	89	11	118	85	- 16	116	79	- 7	117	86
329	- 38	107	75	- 17	108	75	- 40	107	73	- 38	108	74
38	- 43	105	71	- 21	106	69	- 44	107	69	- 44	105	69

Comments: Good metal dispersion on zeolite - excellent catalyst activity.

Poor metal dispersion on zeolite - poor catalyst activity.

Poor metal dispersion on zeolite, good metal dispersion on support - good catalyst activity

Dispersion of metal on support can be less than 50% and still give good <u>initial</u> catalyst activity.

CLAIMS:

1. A method for hydroisomerizing a waxy feed to produce improved yield of a lube basestock which comprises: contacting the waxy feed under hydroisomerization conditions with a catalyst comprising a unitized mixed powdered pellet catalyst having (1) a first dewaxing component selected from 8, 10 and 12 ring molecular sieves and mixtures thereof; (2) a second isomerization component which is an amorphous inorganic oxide; and (3) at least one of a Group VIB and a Group VIII metal hydrogenation component, wherein the first and second components are present in a ratio such that when evaluated in the conversion of methyl cyclohexane at 320°C to 1,1-dimethylcyclopentane, 1,2-dimethylcyclopentane, 1,3-dimethylcyclopentane and ethylcyclopentane, the catalyst will provide a trans-1,2-/trans-1,3-dimethylcyclopentane ratio in the range of less than 1 and a selectivity to ethylcyclopentane, at 10% conversion, of at least about 50%.

2. The method of claim 1 wherein the dewaxing component is at least one of a 10 ring and 12 ring molecular sieve.

3. The method of claim 1 wherein the isomerization component is at least one of silica, alumina, titania, zirconia, silica-alumina and silica-magnesia.

4. The method of claim 1 wherein the isomerization component is at least one of silica, alumina, titania and zirconia.

5. The method of claim 1 wherein the isomerization component is alumina.

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6. The method of claim 1 wherein the hydrogenation component is a Group VIII metal.

7. The method of claim 6 wherein the metal is Pt or Pd.

8. The method of claim 6 or 7 wherein the metal is dispersed on both the first dewaxing and second isomerization components.

9. The method of claim 8 wherein the metal dispersion on at least one of the components be at least about 0.3.

10. The method of claim 1 wherein the Group VIB and Group VIII metal hydrogenation component is promoted or doped.

11. The method of claim 1 wherein the waxy feed is solvent dewaxed to a pour point of up to +10°C before hydroisomerization.

12. The method of claim 10 wherein the promoter or dopant is selected from yttria, rare earth oxides, boria and magnesia.

13. A method for hydroisomerizing a waxy feed to produce improved yield of a lube basestock which comprises: contacting the waxy feed under hydroisomerization conditions with a catalyst comprising a unitized mixed powdered pellet catalyst having (1) a first dewaxing component selected from 8, 10 and 12 ring molecular sieves and mixtures thereof; (2) a second isomerization component which is an amorphous inorganic oxide; and (3) at least one of a Group VIB and a Group VIII metal hydrogenation component, wherein the first

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and second components are present in a ratio such that when evaluated in the conversion of methyl cyclohexane at 320°C to 1,1-dimethylcyclopentane, 1,2-dimethylcyclopentane, 1,3-dimethylcyclopentane and ethylcyclopentane, the catalyst will provide a trans-1,2-/trans-1,3-dimethylcyclopentane ratio in the range of at least 1 and a selectivity to ethylcyclopentane, at 10% conversion, of at least about 50%.