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(54) **METHOD FOR PREPARING A NAPHTHENIC BRIGHTSTOCK FROM A NAPHTHENIC FEEDSTOCK BASED ON NAPHTHENIC DEASPHALTED OIL**

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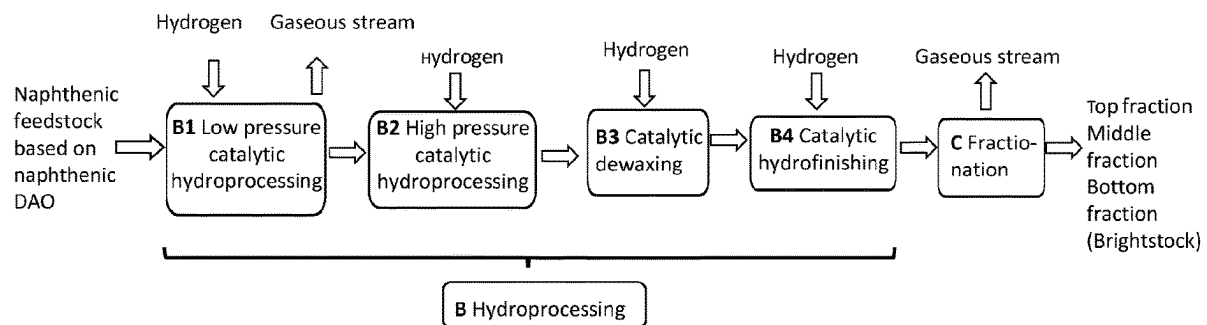
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**ABSTRACT**

A method of preparing a naphthenic brightstock from a naphthenic feedstock based on naphthenic deasphalted oil (DAO) is disclosed. The method includes a hydroprocessing step B, which step is sub-divided into three separate steps; B1 low pressure catalytic hydroprocessing, B2 high pressure catalytic hydroprocessing, and, B3 catalytic dewaxing. The naphthenic brightstock exhibits a reduced viscosity and increased viscosity index as compared to the naphthenic DAO feedstock, and the method allows for a broader range of naphthenic DAO feedstocks to be used for preparing the naphthenic brightstock.



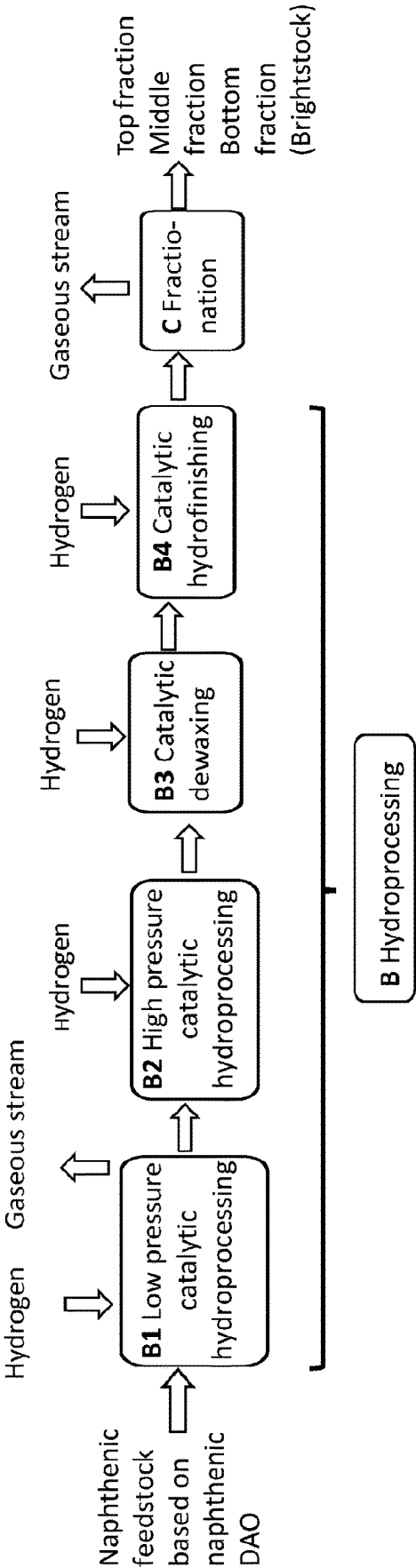


FIG. 1

# METHOD FOR PREPARING A NAPHTHENIC BRIGHTSTOCK FROM A NAPHTHENIC FEEDSTOCK BASED ON NAPHTHENIC DEASPHALTED OIL

## FIELD OF THE INVENTION

[0001] The present invention generally relates to naphthenic brightstocks, and more particularly to a method of preparing, from a naphthenic feedstock based on naphthenic deasphalted oil (DAO), a naphthenic brightstock exhibiting a reduced viscosity and an increased viscosity index as compared to the feedstock, which method allows for a broadened range of naphthenic DAO feedstocks to be used for preparing the brightstock.

## BACKGROUND ART

[0002] Brightstocks are conventionally made from petroleum feedstocks that have been solvent deasphalted and then solvent refined or hydrotreated to provide a modified oil having improved cleanliness or quality. Brightstocks typically are classified as either naphthenic or paraffinic. The classification is usually derived from the nature of the used feedstock. The production of quality naphthenic brightstocks that qualify for use in traditional brightstock applications requires careful selection of processing steps in order to meet target performance characteristics, in particular an appropriate viscosity range and a sufficiently high Viscosity Index (VI), and production costs.

[0003] CN 104449841A teaches that brightstocks are high viscosity lubricating base oils widely used in the production of marine engine oil, single grade and advanced multi-grade engine oil, internal combustion engine oil, heavy duty gear oil, various greases and the like. The brightstocks are classified into 90BS, 120BS and 150BS. Among these, 90BS brightstocks have a kinematic viscosity at 100° C. in a range of from 17 to 22 mm<sup>2</sup>/s, 120BS brightstocks have a kinematic viscosity at 100° C. in a range of from 22 to 28 mm<sup>2</sup>/s, and 150BS brightstocks have a kinematic viscosity at 100° C. in a range of from 28 to 34 mm<sup>2</sup>/s. The higher the kinematic viscosity with respect to the three types, the wider the application range of the brightstocks. CN 104449841A discloses a method for producing a brightstock with a pour point of ≤-18° C. and a kinematic viscosity at 100° C. of ≥28 mm<sup>2</sup>/s. The method utilizes a naphthenic light deasphalted oil having a pour point of ≥0° C. and a kinematic viscosity at 100° C. of ≥60 mm<sup>2</sup>/s. In Table 4, the properties of the resulting brightstock are set forth, i.e. a kinematic viscosity at 100° C. of 33.41 mm<sup>2</sup>/s, and a viscosity index of 92. In Table 1 the properties of the naphthenic light deasphalted oil are set forth, i.e. a kinematic viscosity at 100° C. of 63.50 mm<sup>2</sup>/s, and a viscosity index of 60. The method disclosed therein comprises the following steps (1) a hydrogenation pre-refining reaction process; (2) a hydrogenation isomerization dewaxing reaction process; (3) a hydrogenation supplementary refining reaction process; and, a product separation process.

[0004] WO 2016/044646 also discloses a process for producing naphthenic brightstocks. In Table 7 therein, the properties of a dewaxed/hydrofinished brightstock obtained in Example 4 are set forth, i.e. a kinematic viscosity at 100° C. of 43.1 mm<sup>2</sup>/s, and a viscosity index of 81. In Tables 5 and 6 properties of the DAO feedstock used, and of the resulting dewaxed/hydrofinished brightstock are shown.

From said tables it can be seen that the kinematic viscosity at 100° C. and the viscosity index of the resulting brightstock are similar to the kinematic viscosity at 100° C. and the viscosity index of the DAO feedstock used.

[0005] It would be desirable to broaden the range of useful naphthenic DAO feedstocks for preparing a naphthenic brightstock having a reduced viscosity and increased viscosity index as compared to that of the naphthenic feedstock used.

[0006] It is therefore an object of the present invention to provide a method allowing for a broader range of naphthenic DAO feedstocks to be used for obtaining a naphthenic brightstock having a reduced viscosity and an increased viscosity index as compared that of the naphthenic DAO feedstock used.

## SUMMARY OF THE INVENTION

[0007] According to the present invention the above object has been achieved by means of a method comprising the steps of: A providing a naphthenic feedstock based on naphthenic DAO; B hydroprocessing of the naphthenic feedstock based on naphthenic DAO to obtain a hydroprocessed product; and, C fractionation of the hydroprocessed product, so as to obtain a naphthenic brightstock, wherein the viscosity of the naphthenic feedstock in step A is within the range of 45-65 mm<sup>2</sup>/s at 100° C., wherein the hydroprocessing step B comprises the following three separate steps: B1 low pressure catalytic hydroprocessing of the naphthenic feedstock based on naphthenic deasphalted oil, thereby obtaining a low pressure catalytically hydroprocessed liquid product, wherein the low pressure catalytic hydroprocessing step B1 is carried out within a hydrogen partial pressure range of 5.0-7.0 MPa; B2 high pressure catalytic hydroprocessing of the low pressure catalytically hydroprocessed liquid product leaving from the low pressure catalytic hydroprocessing step B1, thereby obtaining a high pressure catalytically hydroprocessed product, wherein the high pressure catalytic hydroprocessing step B2 is carried out within a hydrogen partial pressure range of 13-15 MPa; and, B3 catalytic dewaxing of the high pressure catalytically hydroprocessed product leaving from the high pressure catalytic hydroprocessing step B2, thereby obtaining a catalytically dewaxed product which constitutes the hydroprocessed product resulting from step B.

[0008] By means of the inventive method, a naphthenic brightstock having a kinematic viscosity at 100° C. of about 30 mm<sup>2</sup>/s, and a viscosity index of 90 or more, preferably 95 or more, such as 95-100, can be produced from a naphthenic DAO feedstock having a kinematic viscosity of as low as about 45 mm<sup>2</sup>/s. Accordingly, the inventive method can be used for preparing a BS150 brightstock from a naphthenic deasphalted oil feedstock. A higher VI, such as 100 or more, could be obtained by the inventive method, however, at the cost of a lower yield.

[0009] In a preferred embodiment, the hydroprocessing step B additionally comprises a fourth step B4, wherein the catalytically dewaxed product leaving from the catalytic dewaxing step B3 is subjected to catalytic hydrofinishing, thereby obtaining a catalytically hydrofinished product which constitutes the hydrofinished product resulting from step B.

[0010] Further embodiments and advantages of the invention will be apparent from the following detailed description and appended claims.

[0011] As used herein the term “naphthenic feedstock based on naphthenic deasphalted oil” is intended to refer to a naphthenic feedstock comprising at least 50% by weight, preferably at least 70% by weight, and more preferably at least 90% by weight of a naphthenic deasphalted oil. The remainder of the naphthenic feedstock may be selected from hydrocarbon mixtures and fractions having a 5 wt % boiling point of  $\geq 310^{\circ}\text{C}$ ., preferably of  $\geq 370^{\circ}\text{C}$ ., and a density of  $\geq 900\text{ kg/m}^3$ , preferably of  $\geq 930\text{ kg/m}^3$ .

[0012] As used herein, the term “catalytic dewaxing” is intended to be synonymous with the term “hydrowaxing” as used in the art.

[0013] The term “naphthenic” as used herein with respect to the feedstock refers to a feedstock consisting of at least about 30% CN (naphthenic hydrocarbon content) and less than about 70% in total of a combined amount of  $C_P$  (paraffinic hydrocarbon content) and  $C_A$  (aromatic hydrocarbon content) as measured according to the Brandes IR method (Brandes et al., 1956).

[0014] The term “naphthenic brightstock” as used herein refers to a brightstock which has been prepared according to the inventive method from a naphthenic feedstock as defined above with reference to the Brandes IR method. Typical brightstock applications require a VI of 90 or more. The inventive naphthenic brightstock itself, however, may or may not be naphthenic as defined above with reference to the Brandes IR method.

#### BRIEF DESCRIPTION OF THE ATTACHED DRAWING

[0015] FIG. 1 shows a flow chart of a preferred embodiment of the inventive method, wherein the fractionation step C results in three streams, a bottom fraction constituting the brightstock, a middle fraction, and a top fraction, respectively, and wherein a catalytic hydrofinishing step B4 also is included.

#### DETAILED DESCRIPTION OF THE INVENTION

[0016] According to the invention, the hydroprocessing step B is divided into three separate steps (B1, B2, B3). By virtue of the separation into three separate steps, a lower viscosity feedstock can be used in the inventive method.

[0017] The viscosity of the naphthenic feedstock based on naphthenic DAO is preferably within the range of 50-60  $\text{mm}^2/\text{s}$  at  $100^{\circ}\text{C}$ ., such as about 55  $\text{mm}^2/\text{s}$  at  $100^{\circ}\text{C}$ .

[0018] The aromatic content of the naphthenic feedstock based on naphthenic DAO is below 40%, preferably within the range of 15-30%.

[0019] The low pressure catalytic hydroprocessing step B1 is preferably carried out within a temperature range of 340-375 $^{\circ}\text{C}$ . In the low pressure catalytic hydroprocessing step B1, a preferred LHSV is within the range of 0.1-0.4 h-1. A preferred hydrogen to oil ratio in step B1 is within the range of 300-700  $\text{Nm}^3/\text{m}^3$ . A commercially available hydrotreating catalyst or a combination of two or more such catalysts is used in step B1. An example of a suitable type of hydrotreating catalyst is a hydrodemetallization catalyst. The one or more catalysts used in step B1 are preferably intended for vacuum gas oils. According to the invention, a catalyst used in step B1 is preferably a base metal catalyst, such as a catalyst based on Ni, Mo, Co, W, or on a combination of any thereof.

[0020] The high pressure catalytic hydroprocessing step B2 is preferably carried out within a temperature range of 370-420 $^{\circ}\text{C}$ . In the high pressure catalytic hydroprocessing step B2, a preferred LHSV is within the range of 0.7-1.4 h-1. A preferred hydrogen to oil ratio in step B2 is within the range of 700-1400  $\text{Nm}^3/\text{m}^3$ , more preferably 1200-1400  $\text{Nm}^3/\text{m}^3$ . A commercially available hydrotreating catalyst or hydrocracking catalyst, or a combination of two or more such catalysts is used in step B2. The one or more catalysts used in step B2 are preferably intended for vacuum gas oils. Suitable catalysts for use in this step are base metal catalysts, such as a catalyst based on Ni, Mo, Co, W, or on a combination of any thereof.

[0021] The catalytic dewaxing step B3 is preferably carried out within a temperature range of 240-370 $^{\circ}\text{C}$ ., more preferably 240-290 $^{\circ}\text{C}$ . A hydrogen partial pressure in step B3 is preferably within the range of 2.0-15 MPa. In some embodiments, e.g., wherein it is desired to carry out step B3 without having to reduce the pressure prevailing in the preceding step B2, such as in a case wherein steps B2 and B3 are connected without an intermediate storage of the product from step B2, step B3 can be carried out at a pressure within the range of 13-15 MPa. In other preferred embodiments, e.g., wherein it is desired to keep the energy demand low and/or reduce the requirements on the equipment used, step B3 can be carried out at a pressure within the range of 2.0-7.5 MPa, more preferably 2.0-5.0 MPa. In step B3 a preferred LHSV is within the range of 0.5-2.0 h-1, more preferably 1.0-2.0 h-1. In step B3 a preferred hydrogen to oil ratio is within the range of 200-1400  $\text{Nm}^3/\text{m}^3$ . When step B3 is carried out at a pressure within the range of 13-15 MPa a preferred hydrogen to oil ratio is within the range 700-1400  $\text{Nm}^3/\text{m}^3$ , more preferably 1200-1400  $\text{Nm}^3/\text{m}^3$ . When step B3 is carried out at a pressure within the range of 2.0-7.5 MPa, a preferred hydrogen to oil ratio is within the range of 200-500  $\text{Nm}^3/\text{m}^3$ , more preferably 200-400  $\text{Nm}^3/\text{m}^3$ . A commercially available dewaxing catalyst is used in this step. Suitable catalysts for use in this step are base metal catalysts, such as a catalyst based on Ni, Mo, W, or a combination of any thereof.

[0022] A catalytic hydrofinishing step B4 may preferably be included in the inventive method following step B3. The purpose of step B4 is to adjust certain desired properties of the final product. The most important is to reduce the levels of polyaromatic hydrocarbons, and to stabilize unstable compounds, such as olefins, and products of reactions involving such unstable compounds, such as mercaptans, to improve colour stability and oxidation stability. Unstable compounds, such as olefins, may be formed during the previous steps, and particularly in step B3. Accordingly, in cases where one or more of the above desired product properties are not fulfilled after step B3, a step B4 may preferably be included. When included, the catalytic hydrofinishing step B4 will generally slightly further reduce the viscosity of the product, and slightly further increase the viscosity index of the product, e.g. due to saturation of aromatics.

[0023] When included, the catalytic hydrofinishing step B4 is preferably carried out within a temperature range of 240-370 $^{\circ}\text{C}$ ., more preferably 240-290 $^{\circ}\text{C}$ . A hydrogen partial pressure in step B4 is preferably within the range of 2.0-7.5 MPa, more preferably 2.0-5.0 MPa. In step B4 a hydrogen to oil ratio is preferably within the range of 200-500  $\text{Nm}^3/\text{m}^3$ , more preferably 200-400  $\text{Nm}^3/\text{m}^3$ . In step

B4 a preferred LHSV is within the range of 3-20 h<sup>-1</sup>, more preferably 5-20 h<sup>-1</sup>, and even more preferably 10-17 h<sup>-1</sup>. A commercially available hydrotreating catalyst, or a combination of two or more of such catalysts, is used in this step. Suitable catalysts for use in this step are base metal catalysts, such as a catalyst based on Ni, Mo, Co, W, or on a combination of any thereof.

[0024] In a preferred embodiment, wherein a catalytic hydrofinishing step B4 is included, the catalytic hydrofinishing step B4 is carried out in same reactor as catalytic dewaxing step B3.

[0025] In the process taught in CN 104449841A, the catalytic dewaxing step is comprised in a hydrogenation isomerization dewaxing reaction process, in which the hydrogenation pre-refined oil is contacted with an isomerization dewaxing catalyst. The catalysts used in the process taught in CN 104449841A, viz. an isomerization dewaxing catalyst and a supplementary refining catalyst, contain a Group VIII noble metal. The noble metal is Pt and/or Pd and/or Ir in an amount of from 0.3 wt. % to 0.6 wt. %. In the examples only Pt has been used.

[0026] A hydroisomerization catalyst as used in the process of CN 104449841A, however, is typically susceptible to deactivation by nitrogen and sulphur, primarily nitrogen, and thus requires a feed with very low levels of sulphur and nitrogen. For this purpose, a stripping step for removing H<sub>2</sub>S and NH<sub>3</sub> is included, as shown in FIG. 4 in CN 104449841A.

[0027] The inventive method, on the other hand, preferably utilizes base metal catalysts. In the inventive method the low pressure catalytic hydroprocessing step B1 and high pressure catalytic hydroprocessing step B2, which two steps together correspond to the hydrogenation pre-refining reaction process taught in CN 104449841A, are carried out as separate steps. Accordingly, the inventive method may allow for adapting existing low-medium pressure units in order for said units to be capable of being used for the intended purpose, thereby reducing investment cost compared with building greenfield units. The present invention does not require the use of a noble metal catalyst. In preferred embodiments of the inventive method a noble metal catalyst is not used.

[0028] Also, when a base metal catalyst is used in steps B1 and B2, a stripping step for removing nitrogen and sulphur is not required in the inventive method.

[0029] In fact, it may be of benefit not to remove sulphur, but to keep the sulphur in the product, since in some brightstock applications the sulphur acts as a natural oxidation inhibitor.

[0030] Preferably, a base metal catalyst is used in each one of the steps B1, B2, and B3, and, when included, also in step B4.

[0031] The hydroisomerization step described in CN 104449841A occurs at significantly higher pressure than required in the inventive catalytic dewaxing step.

[0032] The fractionation step C takes place in order to separate a bottom fraction containing the brightstock from the product obtained from the hydroprocessing step B. Accordingly, in the fractionation step, the product obtained from the hydroprocessing step B is split into two or more streams, based on boiling point characteristics, wherein the naphthenic brightstock will be obtained as a bottom fraction. The fractionation step C may be performed using methods known to those skilled in the art, such as distillation at

atmospheric or reduced pressure. Distillation performed at reduced pressure, such as vacuum distillation, is preferred. It is preferred that, in the fractionation step C, the product obtained from the hydroprocessing step B is split into at least three streams, i.e. a bottom fraction (brightstock), a middle fraction, and a top fraction. The cut points are chosen so that the resulting product streams have desirable properties, such as flash point and viscosity. Distillation at atmospheric pressure and reduced pressure, respectively, are well known to those skilled in the art and will not be described further herein. If desired, the fractionation could be carried out so as to result in more than three streams, such as e.g. 4, 5, or 6 streams, wherein the brightstock is obtained as a bottom fraction.

[0033] A preferred naphthenic deasphalted oil of the feedstock for use in the inventive method is a naphthenic deasphalted oil which has been obtained from solvent deasphalting using a solvent selected from C<sub>2</sub>-C<sub>8</sub> alkanes, furfural, and N-methyl-2-pyrrolidone, and preferably propane.

[0034] The feedstock based on naphthenic deasphalted oil preferably comprises at least 90% by weight of a naphthenic deasphalted oil, and more preferably essentially consists of a naphthenic deasphalted oil, in which latter case the feedstock may be referred to as a naphthenic deasphalted oil feedstock.

[0035] For a better understanding the invention will be described by the following example.

#### Example

[0036] The properties of the feedstock based on naphthenic deasphalted oil the DAO that was used in the experiments are shown in Table 1.

[0037] Properties of the feedstock based on naphthenic deasphalted oil used in the experiments. The feedstock used was 100% DAO. The DAO had been obtained from solvent deasphalting of a vacuum residue from a naphthenic crude. The solvent used in the deasphalting, was propane. A super critical solvent extraction unit was used.

[0038] The properties listed in the tables below were established using the following standard methods:

- [0039] Density: ASTM D7042
- [0040] Viscosity at 40° C.: ASTM D7042
- [0041] Viscosity at 100° C.: ASTM D7042
- [0042] Viscosity index: ASTM D2270
- [0043] CA/CP/CN (IR): ASTM D2150
- [0044] Pour point: ASTM D7346
- [0045] Cloud point: ASTM D7689
- [0046] Sulfur: ASTM D2622
- [0047] Nitrogen: ASTM D4629
- [0048] Simulated distillation: ASTM D2887
- [0049] Refractive index ASTM 1747

TABLE 1

Properties of the naphthenic feedstock based on naphthenic oil		
Property	Unit	Value
Density at 15° C.	[kg/m <sup>3</sup> ]	923
Viscosity at 40° C.	[cSt]	991
Viscosity at 100° C.	[cSt]	42.9
Viscosity index		79
C <sub>A</sub> (IR)	[%]	17.4
C <sub>P</sub> (IR)	[%]	40.8

TABLE 1-continued

Properties of the naphthenic feedstock based on naphthenic oil		
Property	Unit	Value
$C_N$ (IR)	[%]	41.8
Pour point	[° C.]	-12
Cloud point	[° C.]	-7
Sulfur	[ppm]	6810
Nitrogen	[ppm]	1257
Simulated distillation		
5%	[° C.]	487.0
10%	[° C.]	504.0
30%	[° C.]	541.5
50%	[° C.]	570.5
70%	[° C.]	603.0
90%	[° C.]	656.0
95%	[° C.]	682.0

**[0050]** The low pressure catalytic hydroprocessing step 81 was carried out using a CoNiMo catalyst. Step B1 was carried out at two different temperatures while keeping the other parameters constant. The conditions are shown in Table 2. The properties of the liquid product resulting from the low pressure catalytic hydroprocessing step 81 are shown in Table 3.

TABLE 2

Low pressure catalytic hydroprocessing conditions of step B1			
Parameter	Unit	LPHP1	LPHP2
Catalyst		CoNiMo	CoNiMo
Pressure	[MPa]	5.5	5.5
Temperature	[° C.]	355	350
LHSV	[h <sup>-1</sup> ]	0.23	0.23
H <sub>2</sub> /oil	[m <sup>3</sup> /m <sup>3</sup> ]	584	584

TABLE 3

Properties of the liquid product from Low pressure catalytic hydroprocessing step B1			
Property	Unit	LPHP1	LPHP2
Liquid bottom yield	[wt. %]	99.2	99.3
Sulfur	[ppm]	250	381
Nitrogen	[ppm]	299	
Simulated distillation			
5 wt. %	[° C.]	389	428
50 wt. %	[° C.]	556	559
95 wt. %	[° C.]	683	671

**[0051]** The high pressure catalytic hydroprocessing step B2 was carried out using two different base metal catalysts, a NiMo base metal catalyst, and a NiW base metal catalyst, respectively. Step B2 was carried out at two different temperatures while keeping the other parameters constant. The conditions are shown in Table 4. The properties of the liquid product resulting from the high pressure catalytic hydroprocessing step B2 are shown in Table 5.

TABLE 4

High pressure catalytic hydroprocessing conditions of step B2			
Parameter	Unit	HHP1	HHP2
Catalyst		NiMo (20 mL) NiW (40 mL)	NiMo (20 mL) NiW (40 mL)
Pressure	[MPa]	14.0	14.0
Temperature	[° C.]	385	390
LHSV	[h <sup>-1</sup> ]	1.33	1.33
H <sub>2</sub> /oil	[m <sup>3</sup> /m <sup>3</sup> ]	1200	1200

TABLE 5

Properties of the liquid product from high pressure catalytic hydroprocessing step B2			
Parameter	Unit	HHP1	HHP2
Viscosity at 40° C.	[cSt]	286	275
Viscosity at 100° C.	[cSt]	22.2	21.8
Viscosity index	[—]	95	96
Sulfur	[ppm]		7

**[0052]** The catalytic dewaxing step B3 and catalytic hydrofinishing step B4 occur in the same reactor in the example. A NiMo base metal catalyst was used in both steps B3 and B4. The two steps, B3 and B4, respectively, were carried out at two different temperatures while keeping the other parameters constant. The conditions are shown in Table 6. The properties of the liquid product resulting from the catalytic hydrofinishing step B4 are shown in Table 7.

TABLE 6

Catalytic dewaxing (DW) step B3 and catalytic hydrofinishing (HF) step B4 conditions			
Parameter	Unit	DWHF1	DWHF2
Pressure	[MPa]	3.0	3.0
Temperature	[° C.]	275	250
WHSV	[h <sup>-1</sup> ]	1.5	1.5
dewaxing			
WHSV hydrofinishing	[h <sup>-1</sup> ]	15	15
H <sub>2</sub> /oil	[Nm <sup>3</sup> /m <sup>3</sup> ]	250	250

TABLE 7

Properties of the liquid product from catalytic dewaxing step B3 and catalytic hydrofinishing step B4			
Property	Unit	DWHF1	DWHF2
Density	[kg/m <sup>3</sup> ]	890	889
Viscosity at 40° C.	[cSt]	142	147
Viscosity at 100° C.	[cSt]	14.2	14.7
VI	[—]	96	99
$C_A$ (IR)	[%]	7.4	7.0
$C_P$ (IR)	[%]	59.2	60.7
$C_N$ (IR)	[%]	33.5	32.3
Refractive index	[—]	1.4728	1.4724
Pour point (CPP)	[° C.]	-40	-28
Cloud point (MPP)	[° C.]	-24	3
Mass balance	[wt. %]	97.9	99.4
Liquid recovery	[wt. %]	90.9	96.2
Total overhead yield	[wt. %]	7.2	3.3

**[0053]** Two different fractionations of the liquid product from the catalytic hydrofinishing step B4 were carried out. The resulting bottom product properties are shown in table 8.

TABLE 8

Properties of the bottom product, i.e. brightstock, from fractionation step C			
Property	Unit	Batch 1 Cut point 530° C.	Batch 2 Cut point 310° C.
Yield	[wt. %]	61	88
Density	[kg/m <sup>3</sup> ]	888	891
Viscosity at 40° C.	[cSt]	407	222
Viscosity at 100° C.	[cSt]	28.7	18.6
VI	[—]	98	93
C <sub>A</sub> (IR)	[%]	5.5	6.7
C <sub>P</sub> (IR)	[%]	66.7	61.3
C <sub>N</sub> (IR)	[%]	27.8	31.9
Pour point (CPP)	[° C.]	-12	-24
Cloud point (MPP)	[° C.]	12	0

**[0054]** As can be seen from the Example, starting from a naphthenic DAO feedstock having a viscosity at 100° C. of 42.9 cSt and a VI of 79, depending on the selected cut point, a resulting naphthenic brightstock having a viscosity at 100° C. of 28.7 cSt and a VI of 98, or having a viscosity at 100° C. of 18.6 cSt and a VI of 93, can be obtained by means of the inventive method.

**[0055]** While the above example has been described by means of a preferred embodiment of the method, wherein a step B4 is included, it is believed that, in a similar example wherein a step B4 is not included, the resulting naphthenic brightstock will have only a slightly higher viscosity and a slightly lower VI.

1. A method of preparing a naphthenic brightstock comprising the following steps:

A) providing a naphthenic feedstock based on naphthenic deasphalted oil (DAO);

B) hydroprocessing of the naphthenic feedstock based on naphthenic deasphalted oil to obtain a hydroprocessed product; and,

C) fractionation of the hydroprocessed product, so as to obtain a naphthenic brightstock,

wherein the viscosity of the naphthenic feedstock in step (A) is within the range of 45-65 mm<sup>2</sup>/s at 100° C.,

wherein the hydroprocessing step (B) comprises the following three separate steps:

B1) low pressure catalytic hydroprocessing of the naphthenic feedstock based on naphthenic deasphalted oil, thereby obtaining a low pressure catalytically hydroprocessed liquid product, wherein the low pressure catalytic hydroprocessing step (B1) is carried out within a hydrogen partial pressure range of 5.0-7.0 MPa;

B2) high pressure catalytic hydroprocessing of the low pressure catalytically hydroprocessed liquid product leaving from the low pressure catalytic hydroprocessing step (B1), thereby obtaining a high pressure catalytically hydroprocessed product, wherein the high pressure catalytic hydroprocessing step (B2) is carried out within a hydrogen partial pressure range of 13-15 MPa; and,

B3) catalytic dewaxing of the high pressure catalytically hydroprocessed product leaving from the high pressure catalytic hydroprocessing step (B2), thereby obtaining a catalytically dewaxed product which constitutes the hydroprocessed product resulting from step (B).

2. The method of claim 1, additionally comprising a step of solvent deasphalting using a solvent selected from C2-C8 alkanes, furfural, and N-methyl-2-pyrrolidone, and preferably propane, thereby obtaining the naphthenic DAO of the naphthenic feedstock in step (A).

3. The method of claim 1, wherein the viscosity of the feedstock in step (A) is within the range of 50-60 mm<sup>2</sup>/s at 100° C.

4. The method as in any one of the preceding claims, wherein the low pressure catalytic hydroprocessing step (B1) is carried out at one or more conditions selected from the following group of conditions: a temperature within the range of 340-375° C.; an LHSV within the range of 0.1-0.4 h<sup>-1</sup>; and, a hydrogen to oil ratio within the range of 300-700 Nm<sup>3</sup>/m<sup>3</sup>, and preferably at a combination of all conditions.

5. The method as in any one of the preceding claims, wherein the high pressure catalytic hydroprocessing step (B2) is carried out at one or more conditions selected from the following group of conditions: a temperature within the range of 370-420° C.; an LHSV within the range of 0.7-1.4 h<sup>-1</sup>; and, a hydrogen to oil ratio within the range of 700-1400 Nm<sup>3</sup>/m<sup>3</sup>, and preferably at a combination of all conditions.

6. The method as in any one of the preceding claims, wherein the catalytic dewaxing step (B3) is carried out at one or more conditions selected from the following group of conditions: a temperature within the range of 240-370° C.; a hydrogen partial pressure within the range of 2.0-15 MPa, preferably 2.0-7.5 MPa or 13-15 MPa; an LHSV within the range of 0.5-2.0 h<sup>-1</sup>; and, a hydrogen to oil ratio within the range of 200-1400 Nm<sup>3</sup>/m<sup>3</sup>, preferably 700-1400 Nm<sup>3</sup>/m<sup>3</sup> or 200-500 Nm<sup>3</sup>/m<sup>3</sup>, and preferably at a combination of all conditions.

7. The method as in any one of the preceding claims, wherein the hydroprocessing step (B) additionally comprises the following fourth step:

B4) catalytic hydrofinishing of the catalytically dewaxed product leaving from the catalytic dewaxing step (B3), thereby obtaining a catalytic hydrofinished product which constitutes the hydroprocessed product resulting from step (B).

8. The method of claim 7, wherein the catalytic hydrofinishing step (B4) is carried out at one or more conditions selected from the following group of conditions: a temperature within the range of 240-370° C.; a hydrogen partial pressure within the range of 2.0-7.5 MPa; a hydrogen to oil ratio within the range of 200-500 Nm<sup>3</sup>/m<sup>3</sup>; and, an LHSV within the range of 3-20 h<sup>-1</sup>, and preferably at a combination of all conditions.

9. The method of claim 7, wherein the catalytic dewaxing step (B3) and the catalytic hydrofinishing step (B4) both are carried out within one and the same reactor.

10. The method as in any one of the preceding claims, wherein, in steps (B1), (B2), and (B3), and, when included, also in (B4), only base metal catalysts are used.

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