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(54) Titre : UNE METHODE DE TRAITEMENT DES HUILES LOURDES ET DES RESIDUS

(54) Title: A METHOD OF PROCESSING HEAVY OILS AND RESIDUA

(57) **Abrégé/Abstract:**

There is provided a process of treating a heavy hydrocarbon-comprising material, comprising: contacting a feed material with at least a catalyst material within a contacting zone to effect generation of a total product such that a contacting zone material is disposed within the contacting zone and consists of the catalyst material and a feed/product- comprising mixture comprising the feed material and the total product, wherein the feed/product- comprising mixture includes a Conradson carbon residue content of at least 12 weight percent, based on the total weight of the feed/product-comprising mixture, and also includes an asphaltene content of less than two (2) weight percent, based on the total weight of the feed/product- comprising mixture, and wherein the feed material includes deasphalted heavy hydrocarbon- comprising material. A heavy hydrocarbon-containing feed for a catalytic hydroprocessing or catalytic hydrocracking process is also provided, wherein the feed comprises a deasphalted heavy hydrocarbon-comprising material having a Conradson carbon residue, CCR, content greater than about 12 wt% and an asphaltene content less than about 2 wt%. The feed results in reduced catalyst deactivation or catalyst coking during the catalytic hydroprocessing or catalytic hydrocracking process

ABSTRACT

There is provided a process of treating a heavy hydrocarbon-comprising material, comprising: contacting a feed material with at least a catalyst material within a contacting zone to effect generation of a total product such that a contacting zone material is disposed within the contacting zone and consists of the catalyst material and a feed/product-comprising mixture comprising the feed material and the total product, wherein the feed/product-comprising mixture includes a Conradson carbon residue content of at least 12 weight percent, based on the total weight of the feed/product-comprising mixture, and also includes an asphaltene content of less than two (2) weight percent, based on the total weight of the feed/product-comprising mixture, and wherein the feed material includes deasphalted heavy hydrocarbon-comprising material. A heavy hydrocarbon-containing feed for a catalytic hydroprocessing or catalytic hydrocracking process is also provided, wherein the feed comprises a deasphalted heavy hydrocarbon-comprising material having a Conradson carbon residue, CCR, content greater than about 12 wt% and an asphaltene content less than about 2 wt%. The feed results in reduced catalyst deactivation or catalyst coking during the catalytic hydroprocessing or catalytic hydrocracking process

1 **A METHOD OF PROCESSING HEAVY OILS AND RESIDUA**

2 **FIELD**

3 **[0001]** The present disclosure relates to the processing of heavy hydrocarbons.

4 **BACKGROUND**

5 **[0002]** In conventional refineries, fluid catalytic cracking (FCC) is the key process used
6 to convert heavy distillates (vacuum gas oil) into transportation fuels such as gasoline, jet fuel,
7 and diesel. Packed bed hydrotreating and hydroprocessing units are used for removing
8 contaminants and enhancing the feedstock processability prior to further processing. For the
9 past 30 years, tremendous advances have been achieved in FCC and packed bed
10 hydrotreating/hydroprocessing technologies. Some of the improvements to these catalytic
11 refinery processes have been made to their ability to process heavier feedstock, which typically
12 comprises a blend of distillates and certain amount of residua. Currently, many modern
13 refineries are equipped with resid fluid catalytic cracking (RFCC) units and packed bed resid
14 hydroprocessing units to process and convert low-value heavy feedstock into transportation
15 fuels. However, these catalytic processes require stringent feedstock quality specifications to
16 prevent rapid catalyst deactivation and plugging of the catalyst-comprising packed bed. In
17 particular, it has been generally believed that feedstocks with excessive Conradson Carbon
18 Residue (CCR), and/or excessive total metals, would be unsuitable for processing through
19 catalyst material-comprising packed beds. Zuo [Zuo, L., Technology-Economics in
20 Petrochemical, Sinopec Technology and Economic Information Center, 2000, 16(1), 16-21] and
21 Motaghi et al. [Motaghi, M., Subramanian, A. and Ulrich, B., Hydrocarbon Processing, February
22 1, 2011, p. 37-43] suggest that, for RFCC, CCR content should not exceed eight (8) weight
23 percent, based on the total weight of the feedstock, and 20 units of weight of total metals per
24 million units of weight of feedstock. Dai et al. [Dai, L., Hu, Y. and Li, J., Petroleum Processing
25 and Petrochemicals, 2000, 31(12), 13-16] and Threlkel et al. [Threlkel, R., Dillon, C., Singh,
26 U.G. and Ziebarth, M.S., Proceedings of Japan Petroleum Institute International Symposium,
27 November 5-7, 2008] suggest that, for packed bed resid hydroprocessing, CCR content should
28 not exceed 12 weight percent, based on the total weight of feedstock, and 100 units of weight of
29 total metals per million units of weight of feedstock.

1 **[0003]** In this respect, it is generally believed that feedstocks with excessive CCR
2 content, or excessive total metals content, are unsuitable for processing through catalytic
3 material-comprising packed beds [Motaghi, M., Subramanian, A. and Ulrich, B., Hydrocarbon
4 Processing, February 1, 2011, p. 37-43]. Even after subjecting such feedstock to deasphalting,
5 the resultant deasphalted heavy hydrocarbon-comprising material may still be unsuitable for
6 processing through catalytic material-comprising packed beds, and often requires blending with
7 light crude or a lighter hydrocarbon fraction so as to sufficiently dilute the undesirable
8 contaminants to satisfactory concentrations for such processing [de Haan, D. Street, M. and
9 Orzeszko, G., Hydrocarbon Processing, February 1, 2013, p. 41-44].

10 **SUMMARY**

11 **[0004]** In one aspect, there is provided a process of treating a heavy hydrocarbon-
12 comprising material, comprising: contacting a feed material with at least one catalyst material
13 within a contacting zone to effect generation of a total product such that a contacting zone
14 material is disposed within the contacting zone and consists of the catalyst material and a
15 feed/product-comprising mixture comprising the feed material and the total product, wherein the
16 feed/product-comprising mixture includes a CCR content of at least 12 weight percent, based on
17 the total weight of the feed/product-comprising mixture, and also includes an asphaltene content
18 of less than two (2) weight percent, based on the total weight of the feed/product-comprising
19 mixture, and wherein the feed material includes deasphalted heavy hydrocarbon-comprising
20 material.

21 **[0005]** In another aspect, there is provided a process of treating a heavy hydrocarbon-
22 comprising material, comprising: contacting a feed material with at least a catalyst material
23 within a contacting zone to effect generation of a total product such that a contacting zone
24 material is disposed within the contacting zone and consists of the catalyst material and a feed
25 comprising deasphalting a heavy hydrocarbon-comprising material to generate the deasphalted
26 heavy hydrocarbon-comprising material, wherein the feed includes a Conradson carbon residue
27 (CCR) content of at least 12 weight percent, based on the total weight of the feed, and also
28 includes an asphaltene content of less than two (2) weight percent, based on the total weight of
29 the feed.

1 **[0006]** One or more of the following advantages may be realized when practicing the
2 disclosed processes.

3 **[0007]** Heavy crudes and residua can be treated by using conventional refinery
4 processes (such as packed bed resid hydroprocessing or resid fluid catalytic cracking, RFCC)
5 without the use of expensive and energy intensive upgrading processes, resulting in significant
6 reduction in capital and operating costs of processing heavy crudes and residual. There are two
7 conventional heavy crude and resid upgrading process flow sheet options that are generally
8 available to the refiners. The first one is to use either coking or ebullated bed hydroprocessing
9 to upgrade the high CCR and/or metals content feedstocks. The alternative is to subject the
10 high CCR and/or metals content feedstock to solvent deasphalting to produce a lower CCR
11 and/or metals content deasphalted oil (DAO) which is diluted with a refinery intermediate stream
12 such vacuum gas oil. The DAO and vacuum gas oil mixture is further processed in the refinery
13 processes [de Haan, D. Street, M. and Orzeszko, G., Hydrocarbon Processing, February 1,
14 2013, p. 41-44]. However, either coking or ebullated bed hydroprocessing is still required to
15 process the bottoms stream from the solvent deasphalting unit. In any case, the current
16 commercial resid upgrading requires capital costs of at least US\$10,000-50,000 per barrel of
17 feedstock and operating costs of at least US\$10-15 per barrel of feedstock. In contrast, the
18 presently disclosed processes require capital costs of about US\$1,500-2,000 per barrel of
19 feedstock and operating costs of about US\$1.00-1.50 per barrel of feedstock.

20 **[0008]** The heavy hydrocarbon-comprising material feed, of the presently disclosed
21 processes, that is derived from deasphalting operations, require less intensive hydrogen
22 addition, versus coking-derived (thermally cracked) liquid products, and, therefore, provides a
23 benefit of a significant reduction in hydrogen uptake per barrel and lower catalyst deactivation
24 rate. It is generally known that the coking derived (thermally cracked) liquid products are highly
25 hydrogen deficient and require at least 1,200-1,600 standard cubic feet of hydrogen to
26 hydrotreat a barrel of coker product. On the other hand, the heavy hydrocarbon-comprising
27 material feed, of the presently disclosed processes, may only require about 800 standard cubic
28 feet of hydrogen to hydrotreat a barrel of such heavy hydrocarbon-comprising material. In
29 ebullated bed hydroprocessing, the hydroprocessing catalysts are deactivated quickly by high
30 CCR and/or metals content feedstocks. On the other hand, the heavy hydrocarbon-comprising

1 material feed resulting from the presently disclosed processes, would not deactivate
2 hydroprocessing catalysts to the same extent.

3 **[0009]** Carbon dioxide (CO₂) emissions per barrel may be reduced by as much as 40
4 percent compared to conventional heavy crude upgrading operations, when using the heavy
5 hydrocarbon-comprising material feed of the presently disclosed processes. In most heavy
6 crude upgraders, steam-methane reforming is used to produce the required hydrogen and by-
7 product CO₂. Since the disclosed processes require at least 40 percent less hydrogen (to effect
8 hydrotreating of the heavy hydrocarbon-comprising material feed, of the presently disclosed
9 processes) versus the coker-based upgrading operation, the CO₂ emissions will be 40 percent
10 less.

11 **[0010]** The heavy hydrocarbon-comprising material feed, of the presently disclosed
12 processes, has high density and superior feedstock characteristics, resulting in high yield of
13 good quality refined finishing products. High density feedstocks generally contain large
14 hydrocarbon molecules. Compared to a small hydrocarbon molecule, a large hydrocarbon
15 molecule produces a relatively high liquid yield and low gas yield when it is subjected to catalytic
16 cracking with and without the presence of hydrogen. Also compared to a highly hydrogen
17 deficient and aromatic coker products, the products derived from the disclosed processes are
18 virgin feedstock which have good characteristics for catalytic cracking and produces high quality
19 refined finishing products.

20 **[0011]** Use of the heavy hydrocarbon-comprising material feed, of the presently
21 disclosed processes, effects a significant reduction in refinery by-products and overall
22 hydrocarbon losses. For example, in the coking process, the oilsands bitumen which contains
23 14 weight percent CCR and 16 weight percent asphaltenes, produces 20 weight percent by-
24 product coke and 10 weight percent of by-product gases. In contrast, the disclosed processes
25 produce 16 weight percent by-product asphaltenes. This is believed to be related to the fact that
26 the disclosed processes are physical separation processes, capable of selective removal of
27 asphaltenes from oilsands bitumen, whereas coking is a high severity thermal cracking reaction
28 process.

29 **[0012]** In another aspect, there is provided a heavy hydrocarbon-containing feed for a
30 catalytic hydroprocessing or catalytic hydrocracking process, the feed comprising a deasphalted

1 heavy hydrocarbon-comprising material having a Conradson carbon residue, CCR, content
2 greater than about 12 wt% and an asphaltene content less than about 2 wt%.

3 **BRIEF DESCRIPTION OF DRAWINGS**

4 **[0013]** The processes of the description will now be discussed with reference to the
5 following accompanying drawings:

6 **[0014]** Figure 1 illustrates a schematic drawing of an aspect of the described process.

7 **[0015]** Figure 2 illustrates a schematic drawing of another aspect of the described
8 process.

9 **[0016]** Figure 3 illustrates a schematic drawing of another aspect of the described
10 process.

11 **[0017]** Figure 4 is a process flow diagram of the process of Example 1.

12 **[0018]** Figure 5 is a process flow diagram of the process of Example 2.

13 **[0019]** Figure 6 illustrates the Fourier transform ion cyclotron resonance mass
14 spectrometry analysis of deasphalted oil (DAO) showing relative abundance (y-axis) and
15 number of double bond equivalents (DBEs), which correlates to the number of aromatic rings.

16 **DETAILED DESCRIPTION**

17 **[0020]** The present invention is based on the results of an experimental program to
18 determine the chemistry of asphaltenes in deasphalted oil (DAO) samples obtained from the
19 selective asphaltene separation process described in U.S. Patent No. 7,597,794 under various
20 operating conditions, specifically the distribution of basic nitrogen compounds of asphaltenes.
21 The findings from this program are discussed below.

22 **[0021]** When the DAO asphaltenes derived from various vacuum residua (see Table 1)
23 were subjected to Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (FT-ICR MS)
24 analysis (see Figure 6), it was found that for DAO with a low asphaltenes content (i.e. up to 2
25 wt%), the distributions of basic nitrogen compounds of asphaltenes were Type 1. In contrast,
26 for DAO with a high asphaltenes content (i.e. greater than 2 wt%), the distributions of basic

1 nitrogen compounds of asphaltenes were Type 2, indicating relatively more highly condensed
2 nitrogen compounds. In summary, the chemistry of DAO asphaltenes is dependent on the DAO
3 asphaltenes content, which is likely due to selective extraction of asphaltenes sub-fractions.

4 **[0022]** As known in the art, highly condensed nitrogen compounds are detrimental to
5 catalytic refining processes, causing rapid catalyst deactivation and catalyst coking. For this
6 reason, the DAO samples with various asphaltenes contents, as listed in Table 1, were
7 subjected to catalytic hydroprocessing screening tests. Specifically, the DAO samples were
8 mixed with hydrogen gas at 9 MPa and the mixture was introduced to a 125 mL continuous
9 catalyst testing unit at 390°C and 0.5 h⁻¹ liquid hourly space velocity (LHSV). The testing unit
10 was packed with five types of catalysts, namely hydrodemetallization, hydrodesulfurization,
11 hydrodenitrogenation, CCR removal, and hydrocracking catalysts, in a grading bed
12 configuration. The pressure drop across the packed catalyst bed reactor was monitored. The
13 results in Table 1 showed that the DAO with less than 2 wt% asphaltenes had a constant
14 differential pressure across the catalyst bed after 18 h of continuous run, indicating no catalyst
15 coking or plugging. For DAO with higher than 2 wt% asphaltenes, a 50 kPa differential pressure
16 increase across the catalyst bed after 7 h of continuous run, indicating catalyst coking or
17 plugging. In an extreme case of DAO with 8.5 wt% asphaltenes, the catalyst reactor was
18 plugged after 2 h of operation. This showed that DAO with higher than 2 wt% asphaltenes was
19 not a suitable feed for packed hydroprocessing processes.

20 **[0023]** **Table 1**

Type of vacuum resid	DAO asphaltenes content, wt%	DAO CCR content, wt%	Type of nitrogen compounds	Remarks
Athabasca	Traces amount	13.0	1	No pressure drop after 18 h
Athabasca	1.5	13.7	1	No pressure drop after 18 h
Athabasca	3.2	14.8	2	50 kPa pressure drop after 8 h
Athabasca	8.5	16.5	2	Catalyst bed plugging after 2 h
Venezuela	Traces amount	13.5	1	No pressure drop after 18 h
Venezuela	1.8	13.9	1	No pressure drop after 18 h
Venezuela	4.1	14.6	2	50 kPa pressure drop after 7 h
Refinery bottoms	Traces amount	13.1	1	No pressure drop after 18 h
Refinery bottoms	1.3	13.5	1	No pressure drop after 18 h

Refinery bottoms	1.7	13.9	1	No pressure drop after 18 h
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2 **[0024]** Referring to Figures 1 to 3, there is provided a process of treating a deasphalted
3 heavy hydrocarbon-comprising material 12.

4 **[0025]** Figure 1 illustrates one aspect of the described process, wherein a feed material
5 10, comprising deasphalted heavy hydrocarbon-comprising material, is routed to a contacting
6 zone, or reaction zone, 14 that comprises a catalyst material 15. The selection of catalyst
7 material 15 would be dependent on the characteristics of feed. In general, the catalyst is one
8 that is suitable for promoting a catalytic reaction for upgrading at least a fraction of the
9 hydrocarbon material contained in the feed material 10, wherein such catalytic reaction occurs
10 within the reaction zone 14. This catalytic upgrading results in the production of a total product
11 material, or upgraded product, 16. Thus, as will be understood, during operation of the process,
12 a reaction zone material is generated within the reaction zone, such reaction zone material
13 consisting of the catalyst material 15 and a feed/product-comprising mixture, wherein the
14 feed/product-comprising mixture comprises the unreacted feed material 10 and the total product
15 material 16. The total product material 16, in turn, comprises the material generated by the
16 upgrading of at least a fraction of hydrocarbon material of the feed material 10.

17 **[0026]** Figures 2 and 3 illustrate another aspect, wherein the process further includes
18 deasphalting a heavy hydrocarbon-comprising material 4 to generate the deasphalted heavy
19 hydrocarbon-comprising material 12.

20 **[0027]** The heavy-hydrocarbon-comprising material 4 may be liquid, semi-solid, or solid,
21 or any combination thereof.

22 **[0028]** In some aspects of the described process, the heavy hydrocarbon-comprising
23 material 4 is a material that includes at least 10 weight percent (wt%) of hydrocarbon-
24 comprising material that boils above 500°C. In some aspects the heavy hydrocarbon-
25 comprising material 4 is a material includes at least 20 weight percent of hydrocarbon-
26 comprising material that boils above 500°C. In some aspects the heavy hydrocarbon-comprising
27 material 4 is a material includes at least 30 weight percent of hydrocarbon-comprising material
28 that boils above 500°C. In some aspects the heavy hydrocarbon-comprising material 4 is a

1 material includes at least 40 weight percent of hydrocarbon-comprising material that boils above
2 500°C. In some aspects the heavy hydrocarbon-comprising material 4 is a material includes at
3 least 50 weight percent of hydrocarbon-comprising material that boils above 500°C. In some
4 aspects the heavy hydrocarbon-comprising material 4 is a material includes at least 60 weight
5 percent of hydrocarbon-comprising material that boils above 500°C. In some aspects the heavy
6 hydrocarbon-comprising material 4 is a material includes at least 70 weight percent of
7 hydrocarbon-comprising material that boils above 500°C. In some aspects the heavy
8 hydrocarbon-comprising material 4 is a material includes at least 75 weight percent of
9 hydrocarbon-comprising material that boils above 500°C. In some aspects the heavy
10 hydrocarbon-comprising material 4 is a material includes at least 80 weight percent of
11 hydrocarbon-comprising material that boils above 500°C. In some aspects the heavy
12 hydrocarbon-comprising material 4 is a material includes at least 90 weight percent of
13 hydrocarbon-comprising material that boils above 500°C. In some aspects the heavy
14 hydrocarbon-comprising material 4 is a material that boils above 500°C.

15 **[0029]** In some aspects the heavy hydrocarbon-comprising material 4 includes a CCR
16 content of at least 12 weight percent (wt%), based on the total weight of the heavy hydrocarbon-
17 comprising material. In particular, the CCR content of the material 4 is between 12 to 30 wt%.
18 In some aspects the heavy hydrocarbon-comprising material 4 includes a CCR content of at
19 least 13 weight percent (wt%), based on the total weight of the heavy hydrocarbon-comprising
20 material. In some aspects the heavy hydrocarbon-comprising material 4 includes a CCR
21 content of at least 14 weight percent (wt%), based on the total weight of the heavy hydrocarbon-
22 comprising material. In some aspects the heavy hydrocarbon-comprising material 4 includes a
23 CCR content that is less than 30 weight percent (wt%), based on the total weight of the heavy
24 hydrocarbon-comprising material.

25 **[0030]** In some aspects of the described process, the heavy hydrocarbon-comprising
26 material 4 includes an asphaltene content of less than 40 weight percent, based on the total
27 weight of the heavy hydrocarbon-comprising material. In some of these aspects, the heavy
28 hydrocarbon-comprising material includes an asphaltene content of less than 20 weight percent,
29 based on the total weight of the heavy hydrocarbon-comprising mixture. In some of these
30 aspects, the heavy hydrocarbon-comprising material includes an asphaltene content of less

1 than 15 weight percent, based on the total weight of the heavy hydrocarbon-comprising
2 material.

3 **[0031]** In some aspects of the described process, the heavy hydrocarbon-comprising
4 material 4 includes an inorganic solids content of less than one (1) weight percent, based on the
5 total weight of the heavy hydrocarbon-comprising material. In some of these aspects, the heavy
6 hydrocarbon-comprising material includes an inorganic solids content of less than 0.5 weight
7 percent, based on the total weight of the heavy hydrocarbon-comprising material.

8 **[0032]** In some aspects of the described process, the inorganic solids of the heavy
9 hydrocarbon-comprising material 4 may be micrometer (10^{-6} m) sized particles, which can be
10 determined by high temperature filtration technique. In some aspects, the inorganic solids in the
11 heavy hydrocarbon-comprising material 4 may be sub-micron (smaller than 10^{-6} m) sized
12 particles, which can be determined by ultra-high speed centrifugation of the diluted heavy
13 hydrocarbon-comprising material 4.

14 **[0033]** In some aspects of the described process, the heavy hydrocarbon-comprising
15 material 4 has an API (American Petroleum Institute) gravity of less than 20° . In some aspects,
16 the heavy hydrocarbon-comprising material 4 has an API gravity of less than 15° . In some
17 aspects, the heavy hydrocarbon-comprising material 4 has an API gravity of less than 12° . In
18 some aspects, the heavy hydrocarbon-comprising material 4 has an API gravity of less than
19 10° . In some aspects, the heavy hydrocarbon-comprising material 4 has an API gravity of less
20 than 5° . In some aspects, the heavy hydrocarbon-comprising material 4 has an API gravity of
21 less than 0° . In some aspects, the heavy hydrocarbon-comprising material 4 has an API gravity
22 of less than -2° . In some aspects, the heavy hydrocarbon-comprising material 4 has an API
23 gravity of less than -4° . In some aspects, the heavy hydrocarbon-comprising material 4 has an
24 API gravity of less than -8° . In some aspects, the heavy hydrocarbon-comprising material 4 has
25 an API gravity of less than -10° .

26 **[0034]** In some aspects of the described process, the heavy hydrocarbon-comprising
27 material 4 includes, or in some aspects, consists of, residuum or resid. Exemplary residua
28 include various heavy crude and refinery fractions as would be known to persons skilled in the
29 art. In this respect, in some aspects, the heavy hydrocarbon-comprising material includes, or in
30 some aspects, consists of, fresh resid hydrocarbon feeds, a bottoms stream from a refinery

1 process, such as petroleum atmospheric tower bottoms, vacuum tower bottoms, or a bottoms
2 stream from a coker or a visbreaker or a thermal cracking unit, or a bottoms stream from a fluid
3 catalytically cracked (FCC) or a RFCC unit, hydrocracked atmospheric tower or vacuum tower
4 bottoms, straight run vacuum gas oil, hydrocracked vacuum gas oil, FCC slurry oils or cycle oils,
5 as well as other similar hydrocarbon-comprising materials, or any combination thereof, each of
6 which may be straight run, process derived, hydrocracked, or otherwise partially treated
7 (desulfurized). The heavy hydrocarbon-comprising material 4 described herein may also include
8 various impurities, such as sulphur, nitrogen, oxygen, halides, and metals.

9 **[0035]** In some aspects of the described process, the heavy hydrocarbon-comprising
10 material 4 includes, or in some aspects, consists of, a crude, such as a heavy and/or an ultra-
11 heavy crude. Crude refers to hydrocarbon material which has been produced and/or retorted
12 from hydrocarbon-containing formations and which has not yet been distilled and/or fractionally
13 distilled in a treatment facility to produce multiple components with specific boiling range
14 distributions, such as atmospheric distillation methods and/or vacuum distillation methods.
15 Exemplary crudes include coal derived liquids, bitumen, tar sands, or crude oil.

16 **[0036]** As discussed further herein, and as illustrated in Figures 2 and 3, the heavy
17 hydrocarbon material used in the presently described process is preferably first subjected to a
18 deasphalting step. Alternatively, the presently described process includes a deasphalting step.
19 Such deasphalting results in the production of the deasphalted heavy hydrocarbon-comprising
20 material 12. As will be understood by persons skilled in the art, the asphaltene content of the
21 deasphalted heavy hydrocarbon-comprising material 12 would generally be less than the
22 asphaltene content of the heavy hydrocarbon-comprising material 4. As discussed further
23 below, the deasphalting step may involve any known method, such as a solvent extraction
24 process or a reactive process etc. In a preferred aspect, the deasphalting step results in a
25 hydrocarbon material containing up to 2% asphaltenes.

26 **[0037]** In some aspects of the described process, the step of deasphalting is effected by
27 solvent extraction, as is well known in the art. Examples of such solvent extraction methods are
28 described in, for example, the article by Billon and others published in 1994 in Volume 49, No. 5
29 of the journal of the French Petroleum Institute, pages 495 to 507, in the book "Raffinage et
30 conversion des produits lourds du petrole [Refining and Conversion of Heavy Petroleum
31 Products]" by J. F. Le Page, S. G. Chatila, and M. Davidson, Edition Technip, pages 17-32.

1 Exemplary solvent extraction processes, for effecting the deasphalting, are also described in
2 U.S. Patent No. 7,597,794.

3 **[0038]** In some aspects of the described process, the deasphalting is effected by
4 contacting the heavy hydrocarbon-comprising material 4 with solvent material 6, within a solvent
5 material contacting zone 8 (or 8A), to effect production of a mixture including an asphaltene-
6 depleted heavy hydrocarbon comprising material intermediate 12 and an asphaltene-enriched
7 solvent material intermediate 11.

8 **[0039]** In some aspects of the described process, the solvent material that is used for
9 the deasphalting is a hydrocarbon material which is a liquid at the operating conditions of the
10 solvent material contacting zone. In some aspects, the solvent material is a relatively light
11 hydrocarbon or a mixture including two or more light hydrocarbons. Exemplary light
12 hydrocarbons include propane, butane, isobutane, pentane, isopentane, hexane, heptane, and
13 corresponding mono-olefinic hydrocarbons, and corresponding cyclic hydrocarbons. In some
14 aspects, the solvent material includes one or more paraffinic hydrocarbons having from 3 to 7
15 carbon atoms in total per molecule.

16 **[0040]** In some aspects of the described process, the solvent material used for the
17 deasphalting step is a supercritical fluid at the operating conditions of the solvent material
18 contacting zone 8 or 8A.

19 **[0041]** In some aspects of the described process, the solvent material is pentane.

20 **[0042]** The mixture, resulting from the contacting zone, is preferably separated, within a
21 separation zone, as shown at 8 or 8B, into at least the asphaltene-depleted heavy hydrocarbon-
22 comprising material fraction 12 and the asphaltene-enriched solvent material fraction 11. The
23 asphaltene content of the asphaltene-depleted heavy hydrocarbon-comprising fraction 12 is less
24 than the asphaltene content of the heavy hydrocarbon-comprising material 4. As will be
25 understood, other fractions may also be separated during the separation step.

26 **[0043]** In some aspects of the described process, the above mentioned separation step
27 is effected by gravity separation. In other aspects, the separation is effected by phase
28 separation. In other aspects, the separation is effected by an extraction process. Generally, the
29 asphaltene-enriched solvent material fraction 11, which would have a higher density than the

1 asphaltene-depleted heavy hydrocarbon-comprising material fraction 12, is recovered as a
2 bottoms product, and the asphaltene-depleted heavy hydrocarbon-comprising material fraction
3 12 is recovered as an overhead product.

4 **[0044]** Referring to Figure 2, in one aspect, both the contacting and separation steps are
5 conducted within a combined contactor/separator 9, such as a mixer-decanter or an extraction
6 column. In this respect, the solvent material contacting zone and the separation zone are at
7 least partially co-located within zone 8.

8 **[0045]** Referring to Figure 3, in another aspect, the contacting and separation steps are
9 conducted in separate units. For example, as illustrated in Figure 3, the contacting step is
10 effected within unit 9A, which is preferably a mixer, having a mixing zone 8A. The resulting
11 mixture is then supplied to a separator 9B having a separation zone 8B to effect the separation
12 step. As indicated above, the separation step may comprise a gravity separation.

13 **[0046]** In some aspects of the described process, the contactor/separator 9 may
14 contain bubble trays, packing elements such as rings or saddles, structured trays, or
15 combinations thereof, to facilitate contacting between the heavy hydrocarbon-comprising
16 material and the solvent material. In other aspects, the contactor/separator may be an empty
17 column without any internals.

18 **[0047]** In some aspects of the described process, the contactor/separator 9 is operated
19 such that the temperature within the contacting/separation zone 8 is near or above the
20 pseudocritical temperature T_{pc} of the solvent material, and the pressure within the
21 contacting/separation zone 8 is above the pseudocritical pressure P_{pc} of the solvent material.

22 **[0048]** In some aspects of the described process, the asphaltene-depleted heavy
23 hydrocarbon-comprising material fraction 12 is further separated into at least a solvent-rich
24 fraction, a concentrated asphaltene-depleted lighter oil material fraction and a concentrated
25 asphaltene-depleted heavier hydrocarbon-comprising material fraction. In such case, the
26 concentrated asphaltene-depleted heavier hydrocarbon-comprising material fraction is
27 recovered as the deasphalted heavy hydrocarbon-comprising material 12. As will be
28 understood, other fractions may also be separated. In some of these aspects, the separation is
29 effected by steam stripping, evaporation, distillation, or by a supercritical separation process
30 (i.e., under supercritical conditions). In some of these aspects, solvent material, from the

1 solvent-rich fraction, is recovered for recycle and re-use in the solvent extraction unit operation
2 of the deasphalting step.

3 **[0049]** As shown in Figures 2 and 3, a feed material 10, including the deasphalted
4 heavy hydrocarbon-comprising material 12, is provided in reaction zone 14, in the presence of
5 catalyst material 15, under conditions which effect upgrading of at least a fraction of the
6 hydrocarbon material of the feed material. The catalyst material 15 serves to catalyze the
7 upgrading of the feed material 10.

8 **[0050]** The catalyst material 15 may be any catalyst that is suitable for increasing the
9 rate of chemical reaction(s) which effect the upgrading of at least a portion of the hydrocarbon
10 material in the feed material 10. Upgrading, in this context, will be understood to mean a
11 process wherein hydrocarbon material of the feed material 10 undergoes at least one of the
12 following changes: reduction in the molecular weight; reduction in the boiling point range;
13 reduction in the concentration of asphaltenes; reduction in the concentration of hydrocarbon free
14 radicals; or a reduction of impurities, such as sulphur, nitrogen, oxygen, halides, and metals.

15 **[0051]** In some aspects of the described process, the catalyst 15 comprises particulate
16 material in the shape of cylindrical extrudate, trilobes extrudate, or tetralobes extrudate. In
17 some aspects, the extrudate has a diameter of one (1) millimetre to five (5) millimetres and a
18 length of three (3) millimetres to 30 millimetres. In some aspects, the catalyst material 15 for
19 hydrodemetalization is a cylindrical extrudate having a diameter of three (3) millimetres to five
20 (5) millimetres and a length of three (3) millimetres to 10 millimetres. In some aspects, the
21 catalyst material 15 for hydrodesulfurization is a trilobes extrudate having a diameter of 1.5
22 millimetres to three (3) millimetres and a length of 10 millimetres to 30 millimetres. In some
23 aspects, the catalyst material 15 for hydrodenitrogenation or hydro-CCR removal is a trilobes
24 extrudate having a diameter of one (1) millimetre to two (2) millimetres and a length of 10
25 millimetres to 30 millimetres.

26 **[0052]** In some aspects of the described process, the catalyst material 15 has a pore
27 size of 10 to 30 nanometres, such as 15 to 25 nanometres. Also, in some aspects, the catalyst
28 material 15 has a total pore volume of 0.8 to 2 millilitres per gram of catalyst material, such as 1
29 to 1.5 millilitres per gram of catalyst material. Also, in some aspects, the catalyst material 15

1 has a specific surface area of 150 to 400 square metres per gram of catalyst material,
2 preferable 200-250 square metres per gram of catalyst material.

3 **[0053]** In some aspects of the described process, the ratio of volume of catalyst material
4 15 to volume of feed material 10 within the reaction zone 14 is from 0.5 to 5.0. In some
5 aspects, this ratio is from 1.0 to 2.0.

6 **[0054]** In some aspects of the described process, the reaction residence time of feed or
7 feed/product-comprising mixture to the catalyst material 15 within the reaction zone 14 is at
8 least 10 minutes. In some of these aspects, the reaction residence time is less than 30 minutes.
9 In some of these aspects, the reaction residence time is less than 60 minutes. In some of these
10 aspects, the reaction residence time is less than 90 minutes. In some of these aspects, the
11 reaction residence time is less than 120 minutes.

12 **[0055]** In some aspects of the described process, the contacting of the feed with the
13 catalyst is effected while the feed/product-comprising mixture is being flowed through the
14 contacting zone in response to a driving force.

15 **[0056]** In some aspects of the described process, the catalyst material 15 is suitable for
16 facilitating hydrogen addition that effects the redistribution of hydrogen amongst the various
17 hydrocarbon components of the hydrocarbon material of the feed material, resulting in
18 increased hydrogen/carbon (H/C) atomic ratio of the product material.

19 **[0057]** In some aspects of the described process, the feed material 10 also includes a
20 hydrogen donor. In this regard, hydrogen donor means hydrogen or a compound which is
21 reactive with other materials of the feed material, within the reaction zone, to produce hydrogen.
22 In some of these aspects, the hydrogen donor includes molecular hydrogen, such as diatomic
23 hydrogen (H₂). In some of these aspects, the molecular hydrogen is gaseous.

24 **[0058]** Where the feed material 10 includes a hydrogen donor, such as molecular
25 hydrogen, contacting of the feed with the catalyst 15 effects an upgrading of the hydrocarbon
26 material of the feed material, and such upgrading is generally known as "hydroprocessing". As
27 known in the art, the term "Hydroprocessing" is used to define as the upgrading, in the presence
28 of hydrogen, of hydrocarbon material of the feed material. Hydroprocessing includes
29 hydroconversion, hydrocracking, hydrogenation, hydrotreating, hydrosulphurization,

1 hydrodenitrogenation, hydrodemetallation, hydrodearomatization, and
2 hydrodewaxing. As will be understood, the catalyst material 15 used in the presently described
3 process may comprise a combination of different catalysts for facilitating one or more of the
4 above mentioned reactions. For example, the catalyst material 15 may comprise a combination
5 of five catalysts to catalyze, for example, one or more of hydrodemetalization,
6 hydrodesulphurization, hydrodenitrogenation, CCR removal, and/or hydrocracking of the feed
7 material.

8 **[0059]** In some aspects of the described process, the catalyst material includes a
9 functional catalyst material and a catalyst support material, wherein the functional catalyst
10 material is supported on the catalyst support material. In some aspects, the functional catalyst
11 material comprises 0.1 to 5 weight percent cobalt and 1.2 to 30 weight percent molybdenum. In
12 some aspects, the functional catalyst material comprises 0.1 to 5 weight percent nickel and 1.2
13 to 30 weight percent molybdenum. In some aspects, the functional catalyst material comprises
14 0.1 to 5 weight percent nickel and 2 to 40 weight percent tungsten. In some aspects, the
15 catalyst support material comprises 0 to 15 weight percent zeolite, and 0.1 to 5 weight percent
16 phosphorous, and 20 to 90 weight percent gamma-alumina. In some aspects, the catalyst
17 support material comprises 0 to 15 weight percent zeolite, and 0.1 to 5 weight percent
18 phosphorous, and 20 to 90 weight percent alumina-silica. All values of weight percent are based
19 on the total weight of catalyst material.

20 **[0060]** In some aspects of the described process, in addition to the deasphalted heavy
21 hydrocarbon-comprising material 12, the feed material 10 may additionally include a dilution
22 agent for effecting dilution of the deasphalted heavy hydrocarbon-comprising material 12 prior to
23 the step of contacting the material with the catalyst material 15. As would be known to persons
24 skilled in the art, the step of dilution is preferably effected for mitigating fouling, deactivation, or
25 other degradation of the catalyst material.

26 **[0061]** In some aspects of the described process, the feed material 10 is deasphalted
27 heavy hydrocarbon-comprising material 12, and the deasphalted heavy hydrocarbon-comprising
28 material 12 is supplied to the reaction zone in undiluted form.

29 **[0062]** In some aspects, the reaction zone 14 is disposed within a reaction vessel 18 as
30 shown in Figures 2 and 3.

1 **[0063]** The upgrading described above results in the production of a total product
2 material (upgraded product) 16. As illustrated in Figures 2 and 3, a reaction zone material is
3 disposed within the reaction zone and consists of the catalyst material 15, a feed/product-
4 comprising mixture comprising the feed material 10 and the total product material 16. The total
5 product material 16 includes the material generated by the upgrading of at least a portion of the
6 hydrocarbon material of the feed material 10.

7 **[0064]** The feed/product-comprising mixture has a CCR content of at least 12 weight
8 percent, based on the total weight of the feed/product-comprising mixture, and an asphaltene
9 content of less than two (2) weight percent, based on the total weight of the feed/product-
10 comprising mixture. In some aspects, the feed has a CCR content of at least 12 weight percent,
11 based on the total weight of the feed, and an asphaltene content of less than two (2) weight
12 percent, based on the total weight of the feed.

13 **[0065]** In some aspects of the described process, the CCR content is at least 13 weight
14 percent, based on the total weight of the feed or feed/product-comprising mixture. In some
15 aspects, the CCR content is less than 18 weight percent, based on the total weight of the feed
16 or feed/product-comprising mixture. In some aspects, the CCR content is less than 17 weight
17 percent, based on the total weight of the feed or feed/product-comprising mixture. In some
18 aspects, the CCR content is less than 16 weight percent, based on the total weight of the feed
19 or feed/product-comprising mixture. In some aspects, the CCR content is less than 15 weight
20 percent, based on the total weight of the feed or feed/product-comprising mixture. In some
21 aspects, the CCR content is less than 14 weight percent, based on the total weight of the feed
22 or feed/product-comprising mixture.

23 **[0066]** In some aspects of the described process, the asphaltene content is negligible.
24 In other words, in such aspects, the feed or feed/product-comprising mixture contains
25 substantially no asphaltenes. In this regard, it will be understood that "substantially no
26 asphaltenes" is intended to mean that the asphaltene content is 0 or substantially close to 0,
27 which will be understood to include some trace amounts of asphaltenes.

28 **[0067]** CCR content is defined herein as equal to the value as determined by test
29 method ASTM D4530, Standard Test Method for Determination of Carbon Residue (Micro
30 Method).

1 **[0068]** The asphaltene content of the feed or feed/product-comprising mixture is defined
2 herein by the modified China Petroleum and Petrochemical Industry Standard Test Method
3 SH/T0509-92. In some aspects, the asphaltene content of the feed or feed/product-comprising
4 mixture is defined by ASTM 6560-12, Standard Test Method for Determination of Asphaltenes in
5 Crude Petroleum and Petroleum Products.

6 **[0069]** Total metals content is defined herein as the sum of nickel content and vanadium
7 content as determined by test method ASTM D5708, Standard Test Methods for Determination
8 of Nickel, Vanadium, and Iron in Crude Oils and Residual Fuels by Inductively Coupled Plasma
9 (ICP) Atomic Emission Spectrometry.

10 **[0070]** In some aspects of the described process, the feed/product-comprising mixture
11 includes a total metals content of at least 100 unit weight parts per million unit weight parts of
12 feed/product-comprising mixture. In some of these aspects, the feed/product-comprising
13 mixture includes a total metals content of less than 400 unit weight parts per million unit weight
14 parts of feed/product-comprising mixture. In some aspects, the feed includes a total metals
15 content of at least 100 unit weight parts per million unit weight parts of feed. In some of these
16 aspects, the feed includes a total metals content of less than 400 unit weight parts per million
17 unit weight parts of feed.

18 **[0071]** In some aspects of the described process, the total product 16 is recovered from
19 the reaction zone and discharged from the reaction vessel 18.

20 **[0072]** Further aspects will now be described in further detail with reference to the
21 following non-limiting examples.

22 **[0073]** Example 1

23 **[0074]** Athabasca bitumen-derived vacuum residuum was obtained from a commercial
24 mined oilsands plant in Fort McMurray, Alberta. Figure 4 shows the process scheme of treating
25 the vacuum residuum. The properties of vacuum residuum S301 are shown in Table 2. The high
26 concentrations of metal and CCR data in Table 2 show that the bitumen derived vacuum
27 residuum is a relatively low quality feedstock. Hence, it was selected as a representative
28 feedstock to illustrate an extreme worst case scenario of applying the method of the present

1 description. The common upgrading process used for this type of vacuum residuum is by either
2 coking or ebullated bed hydrocracking.

3 **[0075]** The vacuum residuum S301 was introduced to a one (1) barrel per day
4 continuous pilot scale selective asphaltene separator P301, which is similar to that described in
5 U.S. Patent No. 7,597,794. The selective asphaltene separator P301 used n-pentane as solvent
6 and was operated at 160°C, 5 MPa and solvent-to-oil ratio of 4 (on the weight basis). In the
7 selective asphaltene separator P301, the vacuum residuum S301 was separated into two
8 products: feed S303 and asphaltene granules S304. Table 2 shows that the quality of feed S303
9 was improved, compared to the bitumen vacuum residuum S301. However, the feed S303 still
10 contained 250 ppm metals and 13 weight percent CCR, which exceeds the specified operating
11 guidelines for packed bed resid hydroprocessing (which are 100 ppm metals and 12 weight
12 percent CCR). The unique characteristics of feed S303 was that it was a deep-cut residuum
13 with negligible amount of asphaltenes.

14 **[0076]** The feed S303 was mixed with hydrogen gas S304 at 9 MPa and the mixture
15 was introduced to a 125 mL continuous catalyst testing reactor unit P302 which was operated at
16 390°C and 0.5 h⁻¹ liquid hourly space velocity (LHSV). The catalysts testing reactor unit P302
17 was a commercial apparatus packed with five types of catalysts (a hydrodemetallization
18 catalyst, comprising 0.5 percent nickel and 2.5 percent molybdenum supported on alumina; a
19 hydrodesulfurization catalyst comprising 2.5 percent cobalt and 20 percent molybdenum
20 supported on alumina; a hydrodenitrogenation catalyst comprising 4.0 percent nickel and 25
21 percent molybdenum supported on the alumina; a CCR removal catalyst comprising 5.0 percent
22 nickel and 30 percent molybdenum was supported on the alumina with; and a hydrocracking
23 catalyst comprising 2.5 percent nickel and 25 percent tungsten supported on 10 percent Y
24 zeolite mixed silica-alumina) in grading bed configuration. Prior to the resid hydroprocessing
25 run of the feed S303, the reactor unit P302 had been fed continuously with a feed, similar to
26 feed S303, and derived from an extra heavy crude, for 1500 hours. As a result, the catalysts, in
27 the reactor unit P302, were disposed at an equilibrium state when it was fed with the feed S303
28 and hydrogen gas mixture. The continuous packed bed resid hydroprocessing run with the feed
29 S303 was on-stream for 1500 hours. No pressure drop build-up across the catalyst bed was
30 observed for 1500 hours of continuous operation. This is an indication that no catalyst bed
31 plugging was experienced even though the feedstock contained relatively high concentrations of

1 metals (250 ppm) and a relatively high CCR concentration (13 weight percent) without
2 experiencing catalyst bed plugging, leading to pressure drop build-up across the catalyst bed.

3 **[0077]** The reaction product S307 from the reactor unit P302 was routed to a gas/liquid
4 separator P303 in which the reaction product S307 was separated into gas product S308 and
5 hydrotreated liquid product S309, which were sampled daily for analysis. The data in Table 2
6 show that properties of the hydrotreated liquid product S309 were dramatically improved after
7 resid hydroprocessing, including the yield of 10 weight percent diesel and 40 weight percent
8 hydrotreated heavy gas oil, determined by simulated distillation. More importantly, the
9 hydrotreated liquid product S309 contained 3 ppm metals, 4 weight percent CCR and 45 weight
10 percent saturated hydrocarbons, which are superior characteristics for catalytic cracking
11 feedstock.

12 **[0078]** The results of this example illustrate that, surprisingly, poor-quality heavy crude
13 derived residuum can be processed using a conventional packed bed resid hydroprocessing
14 unit for preparing a feedstock that is suitable for other refinery processes.

15 **[0079]** **Table 2. Properties of S301, S303 and S309**

	S301	S303	S309
Yield, wt% IBP-350°C	0	0	10
350-524°C	0	0	40
Density @20°C, g/cm ³	1.0648	0.9990	0.9486
Molecular weight			545
Carbon, wt%	82.97	82.82	86.22
Hydrogen, wt%	9.65	10.43	11.53
H/C (atomic) ratio	1.39	1.50	1.60
Sulfur, wt%	6	4.8	0.59
Nitrogen, wt%	0.68	0.51	0.36
Nickel, ppm	144	77	2
Vanadium, ppm	357	176	1
Concarbon residue (CCR), wt%	23.3	13	4.2
Saturates, wt%	9.31	18.99	44.80
Aromatics, wt%	43.44	56.24	43.97
Resins, wt%	21.67	24.77	11.23
Asphaltenes, wt%	25.58	ND*	ND*

*ND - Not detectable

1

2 **[0080]** Example 2

3 **[0081]** One of the purposes of a packed bed resid hydroprocessing step is as a
4 feedstock pretreatment for RFCC unit. This example will illustrate that certain heavy
5 hydrocarbon-comprising material can be good feedstock for RFCC unit with low severity resid
6 hydroprocessing. The process of Example 2 is illustrated in Figure 5.

7 **[0082]** Feed S403 was obtained from a commercial selective asphaltene separator
8 P401 located at a refinery [Zhao et al., OGI, April 5, 2010, 52-59]. The selective asphaltene
9 separator P401 was similar to that described in U.S. Patent No. 7,597,794. The feed to the
10 selective asphaltene separator P401 was a blend of heavy crude and refinery residua. Table 3
11 shows the properties of the feed S403, including the fact that it contained high concentrations of
12 metals (280 ppm), CCR (13.5 wt%) and 1.3 wt% asphaltenes. The feed S403 contained a high
13 amount saturated hydrocarbons (40 wt%), which is a good feedstock characteristic for RFCC.
14 Also, our analysis indicated that the chemistry of the feed S403 asphaltenes (1.3 wt%) was not
15 the same as those of typical asphaltenes obtained from conventional deasphalting processes.
16 Exemplary chemical characteristics include the distribution of nitrogen containing compounds in
17 the feed S403 asphaltenes is different from that in typical asphaltenes obtained from
18 conventional deasphalting processes. The feed S403 asphaltenes do not cause
19 hydroprocessing catalyst coking and plugging of packed catalyst bed, whereas typical
20 asphaltenes obtained from conventional deasphalting processes cause hydroprocessing
21 catalyst coking and plugging of packed catalyst bed.

22 **[0083]** The feed S403 was mixed with hydrogen gas S405 at 9 MPa and the mixture
23 was introduced to a 125 mL continuous catalyst testing reactor unit P402 which was operated at
24 390°C and 1.0 h⁻¹ liquid hourly space velocity (LHSV). The catalysts testing reactor unit P402
25 was a commercial apparatus packed with five types of catalysts (a hydrodemetallization
26 catalyst, comprising 0.2 percent nickel and 5 percent molybdenum supported on alumina; a
27 hydrodesulfurization catalyst comprising 2.5 percent cobalt and 25 percent molybdenum
28 supported on alumina; a hydrodenitrogenation catalyst comprising 3.0 percent nickel and 20
29 percent molybdenum supported on the alumina; a CCR removal catalyst comprising 4.0 percent

1 nickel and 25 percent molybdenum was supported on the alumina with; and a hydrocracking
2 catalyst comprising 2.0 percent nickel and 25 percent tungsten supported on 20 percent Y
3 zeolite mixed silica-alumina) in grading bed configuration. Prior to the resid hydroprocessing
4 run of the feed S403, the reactor unit P402 was subjected to pre-sulfiding with 2% carbon
5 disulfide in cyclohexane for 72 hours, followed by pre-coking with Chinese Daqing derived
6 vacuum gas oil for 48 hours. The continuous packed bed resid hydroprocessing run with the
7 feed S403 was on-stream for 400 hours. No pressure drop build-up across the catalyst bed was
8 observed for 400 hours of continuous operation. Surprisingly, even though the feedstock
9 contained such high concentrations of metals (280 ppm), CCR (13.5 wt%) and 1.3 wt%
10 asphaltenes, no catalyst bed plugging, leading to pressure drop build-up across the catalyst
11 bed, was observed.

12 **[0084]** The reaction product S407 from the reactor unit P402 was routed to a gas/liquid
13 separator P403 in which the reaction product S407 was separated into gas product S408 and
14 hydrotreated liquid product S409, which were sampled daily for analysis. The data in Table 3
15 show that properties of hydrotreated liquid product S409 were improved after resid
16 hydroprocessing: 8.5 weight percent CCR and 53 weight percent saturate hydrocarbons.
17 However, the hydrotreated liquid product S409 had a relatively high density (0.934 g/cm³) and
18 relatively high metals concentration (53 ppm), and these values were higher than those
19 prescribed by typical threshold RFCC feedstock specifications. It is generally believed that high
20 density feedstock may cause fluidization instability in a FCC riser reactor, due to interaction of
21 catalyst particles and hydrocarbons, which result in catalyst particle agglomeration. Typically,
22 RFCC feedstock consists of a blend of vacuum residuum and vacuum gas oil.

23 **[0085]** The hydrotreated liquid product S409 was subjected to RFCC test in a 1.5 kg/h
24 continuous modified ARCO type FCC pilot testing unit P404. The continuous RFCC pilot run
25 was on-stream for 24 hours and exhibited a stable and smooth operation. Inspection of spent
26 catalysts indicated that, surprisingly, no catalyst particle agglomeration occurred. As shown in
27 Table 2, the RFCC product yields were in-line with those obtained from the oilsands derived a
28 low yield deasphalted oil [Yui et al., OGJ., January 19, 1988]. In the commercial FCC operation,
29 the coke by-product is combusted in the FCC catalyst regenerator and provided the heat for the
30 FCC process.

1 [0086] This illustrates that surprisingly, poor-quality heavy crude derived residuum, with
2 relatively high asphaltenes content, can be processed using a conventional packed bed resid
3 hydroprocessing unit and RFCC units.

4 [0087] **Table 3. Properties of S403, S409 and S411-415**

	S403	S409		
Yield, wt% Gas			2.66	S411
LPG (C ₃ -C ₄)			17.02	S411
Gasoline			41.85	S412
Diesel			18.79	S413
Slurry oil			9.94	S414
Coke			9.48	S415
Density @20°C, g/cm ³	0.9976	0.9342		
Nickel, ppm	56.00	14.90		
Vanadium, ppm	222.00	38.50		
Concarbon residue (CCR), wt%	13.48	8.45		
Saturates, wt%	40.20	52.96		
Aromatics, wt%	41.70	36.00		
Resins, wt%	16.80	10.10		
Asphaltenes, wt%	1.30	0.90		

5
6

7 [0088] While the subject process has been described with reference to illustrative
8 aspects and examples, the description is not intended to be construed in a limiting sense. Thus,
9 various modifications of the illustrative aspects, as well as other aspects of the invention, will be
10 apparent to persons skilled in the art upon reference to this description. It is therefore
11 contemplated that the appended claims will cover any such modifications or aspects.

12

CLAIMS

1. A process of treating a heavy hydrocarbon-comprising material, comprising:
contacting a feed material with at least a catalyst material within a contacting zone to effect generation of a total product such that a contacting zone material is disposed within the contacting zone and consists of the catalyst material and a feed/product-comprising mixture comprising the feed material and the total product, wherein the feed/product-comprising mixture includes a Conradson carbon residue content of at least 12 weight percent, based on the total weight of the feed/product-comprising mixture, and also includes an asphaltene content of less than two weight percent, based on the total weight of the feed/product-comprising mixture, wherein the feed material includes deasphalted heavy hydrocarbon-comprising material, and wherein the catalyst material in the contacting zone is in the form of a packed bed.
2. The process as claimed in claim 1, comprising at least one of the following (a) to (c) characteristics:
 - (a) the Conradson carbon residue content is less than 18 weight percent, based on the total weight of the feed/product-comprising mixture;
 - (b) the reaction retention time of feed/product-comprising mixture to the catalyst material within the contacting zone is at least 10 minutes;
 - (c) the feed/product-comprising mixture includes a total metals content of at least 100 unit weight parts per million unit weight parts of feed/product-comprising mixture.
3. A process of treating a heavy hydrocarbon-comprising material, comprising:
contacting a feed material with at least a catalyst material within a contacting zone to effect generation of a total product such that a contacting zone material is disposed within the contacting zone and consists of the catalyst material and a feed comprising deasphalted heavy hydrocarbon-comprising material from deasphalting a heavy hydrocarbon-comprising material, wherein the feed includes a Conradson carbon residue content of at least 12 weight percent, based on the total weight of the feed, and also includes an asphaltene content of less than two weight percent, based on the total weight of the feed, and wherein the catalyst material in the contacting zone is in the form of a packed bed.

4. The process as claimed in claim 3, comprising at least one of the following (a) to (c) characteristics:
 - (a) the Conradson carbon residue content is less than 18 weight percent, based on the total weight of the feed;
 - (b) the reaction retention time of feed to the catalyst material within the contacting zone is at least 10 minutes;
 - (c) the feed includes a total metals content of at least 100 unit weight parts per million unit weight parts of feed.
5. The process as claimed in any one of claims 1 to 4, wherein the catalyst material includes particulate material.
6. The process as claimed in any one of claims 1 to 5, wherein the catalyst material has a pore size of 10 to 30 nanometers, a total pore volume of 0.8 to 2 milliliters per gram, and specific surface area of 150 to 400 square meters per gram.
7. The process as claimed in any one of claims 1 to 6, wherein the feed material further includes a hydrogen donor.
8. The process as claimed in claim 7, wherein the hydrogen donor includes molecular hydrogen.
9. The process as claimed in any one of claims 1 to 8, wherein the contacting effects hydroprocessing of at least a fraction of hydrocarbon material of the feed material.
10. The process as claimed in any one of claims 1 to 9, wherein the contacting is effected while the feed/product-comprising mixture is being flowed through the contacting zone in response to a driving force.
11. The process as claimed in any one of claims 1 to 10, wherein the deasphalted heavy hydrocarbon-comprising material includes a Conradson carbon residue content of at least 12 weight percent, based on the total weight of the deasphalted heavy hydrocarbon-comprising

material, and also includes an asphaltene content of less than two (2) weight percent, based on the total weight of the deasphalted heavy hydrocarbon-comprising material.

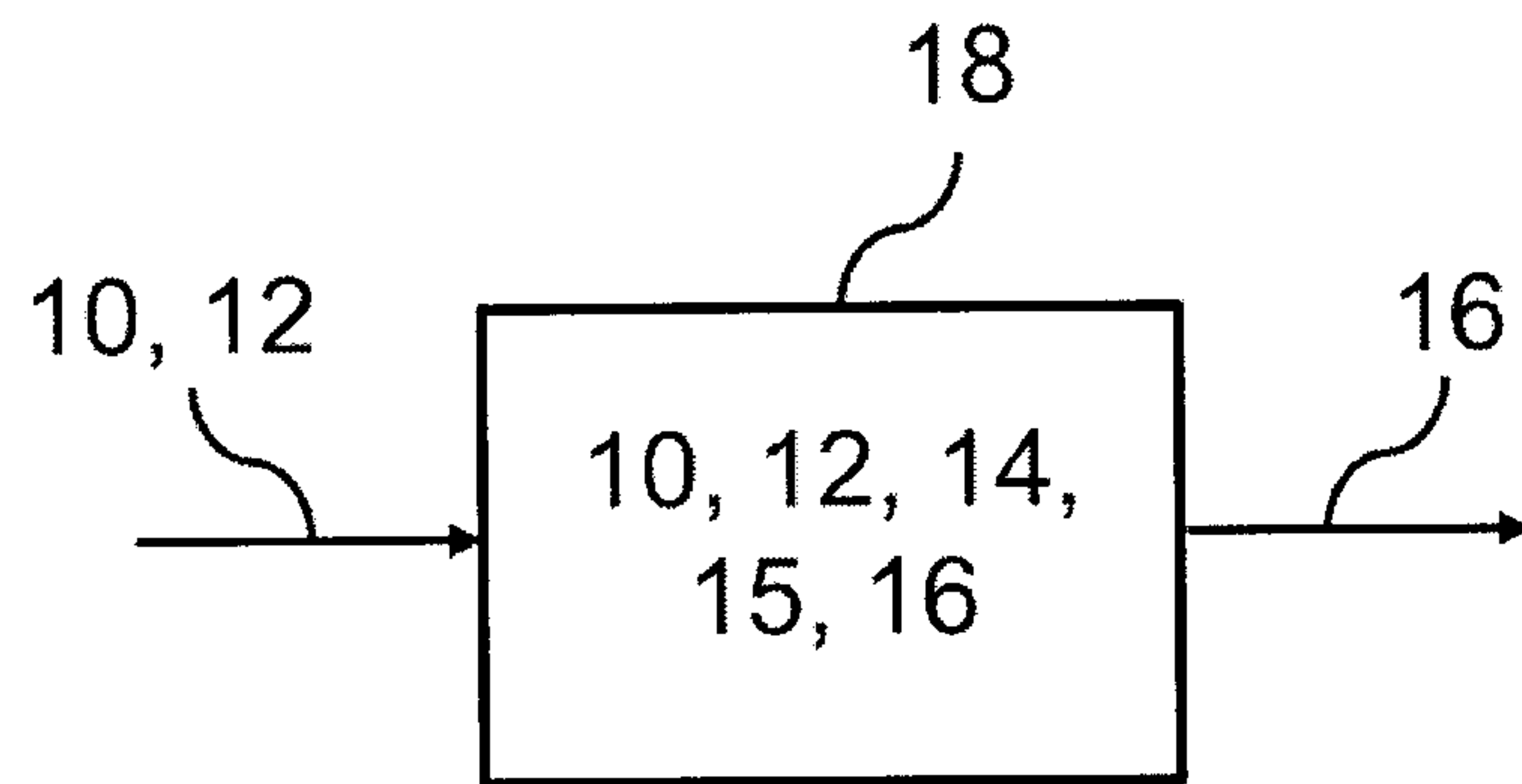
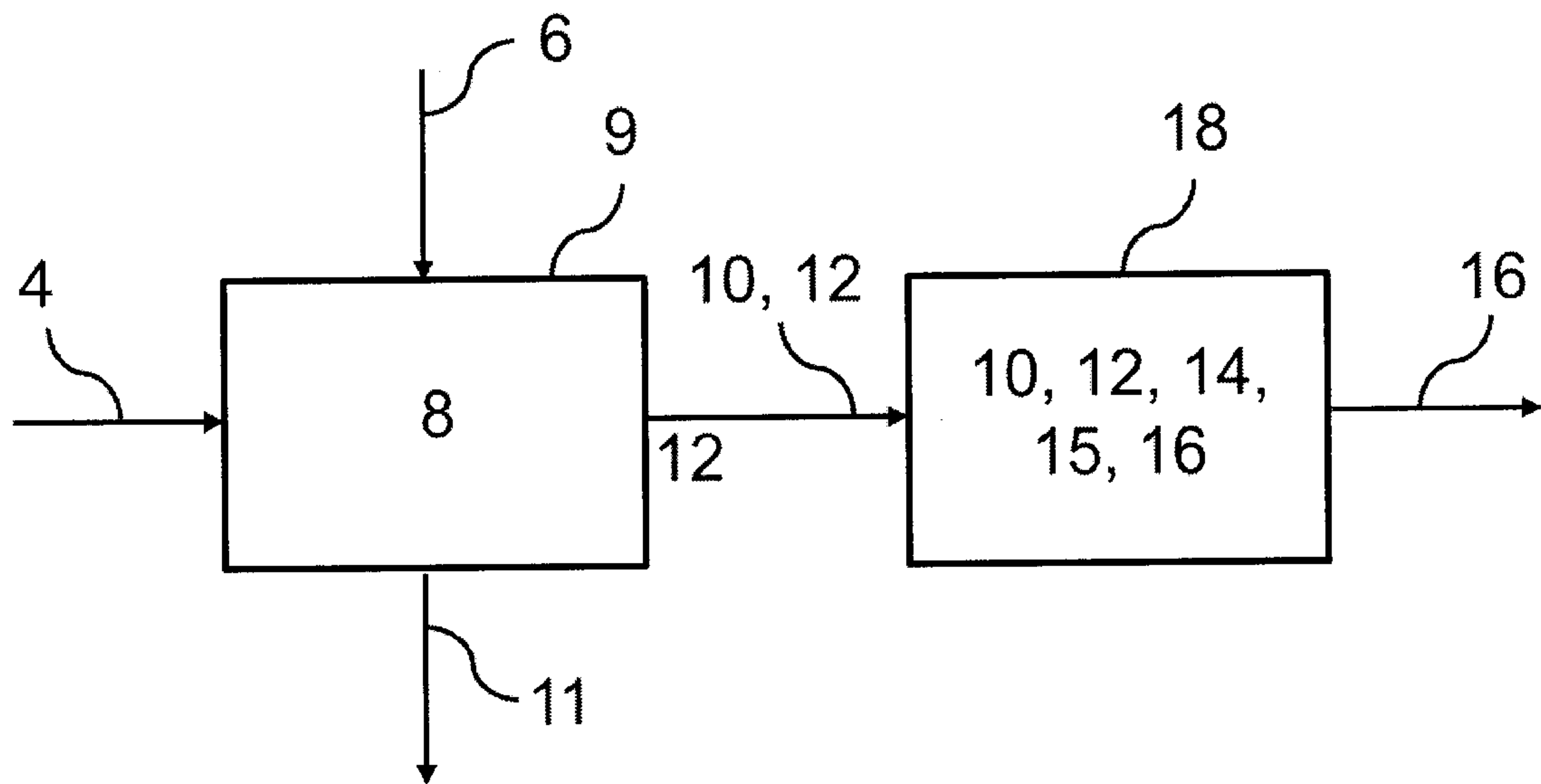
12. The process as claimed in any one of claims 1 to 11, wherein the heavy hydrocarbon-comprising material includes a Conradson carbon residue content of at least 12 weight percent, based on the total weight of the heavy hydrocarbon-comprising mixture, and also includes an asphaltene content of less than 40 weight percent, based on the total weight of the heavy hydrocarbon-comprising mixture.

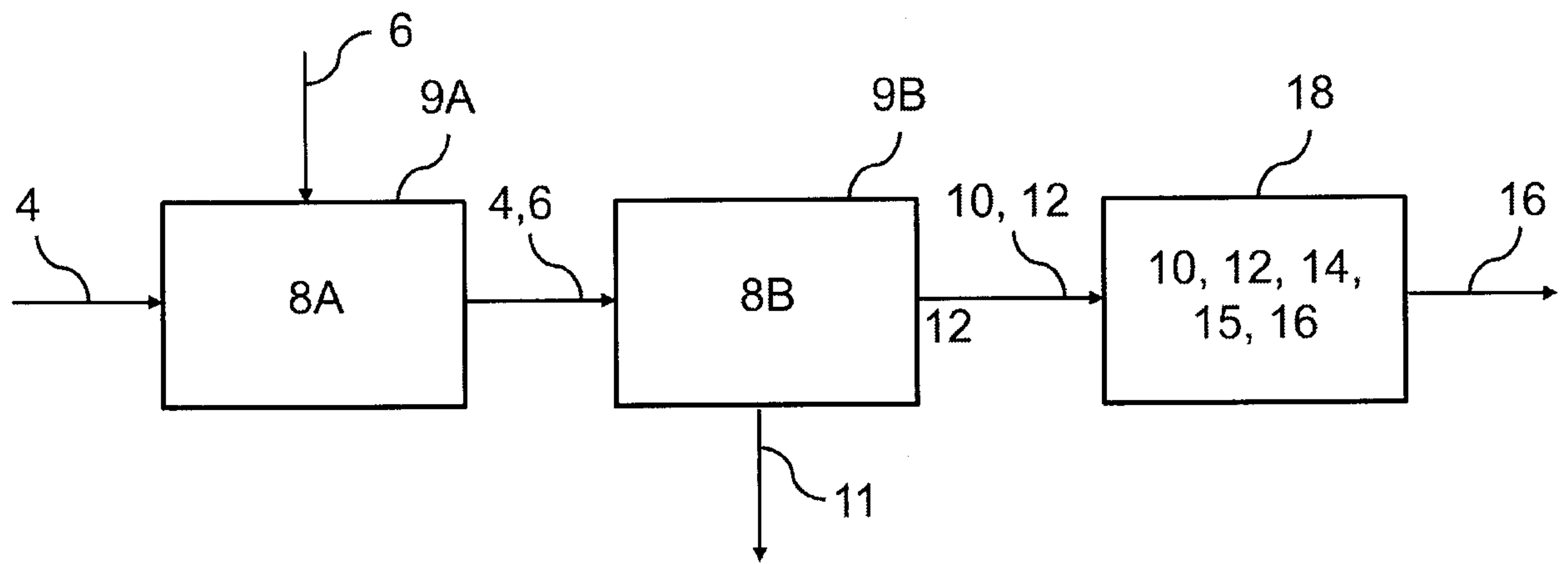
13. The process as claimed in any one of claims 1 to 12, further comprising deasphalting a heavy hydrocarbon-comprising material to generate the deasphalted heavy hydrocarbon-comprising material.

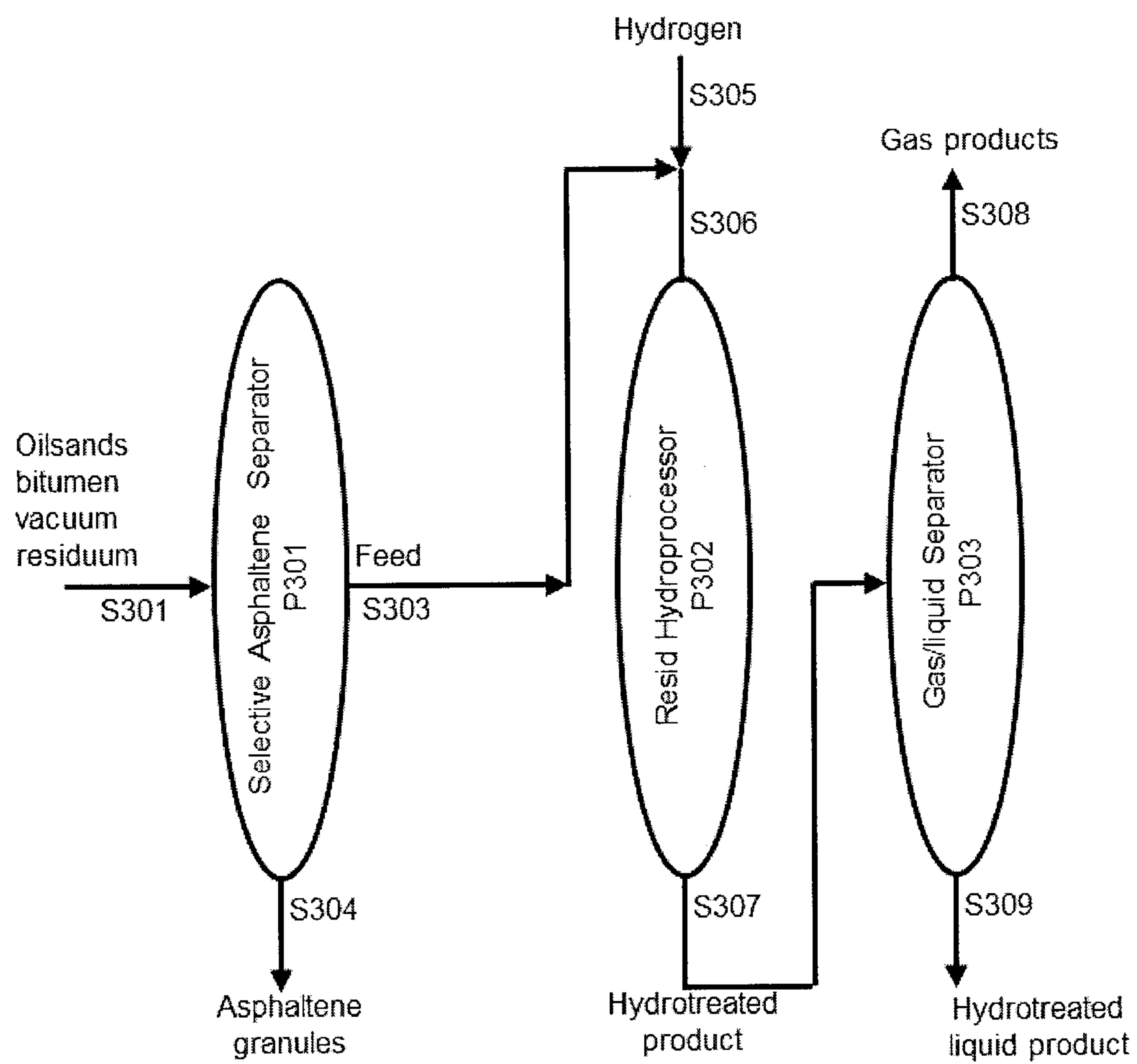
14. The process as claimed in any one of claims 1 to 13, wherein the contacting effects hydroprocessing of at least a fraction of hydrocarbon material of the feed material.

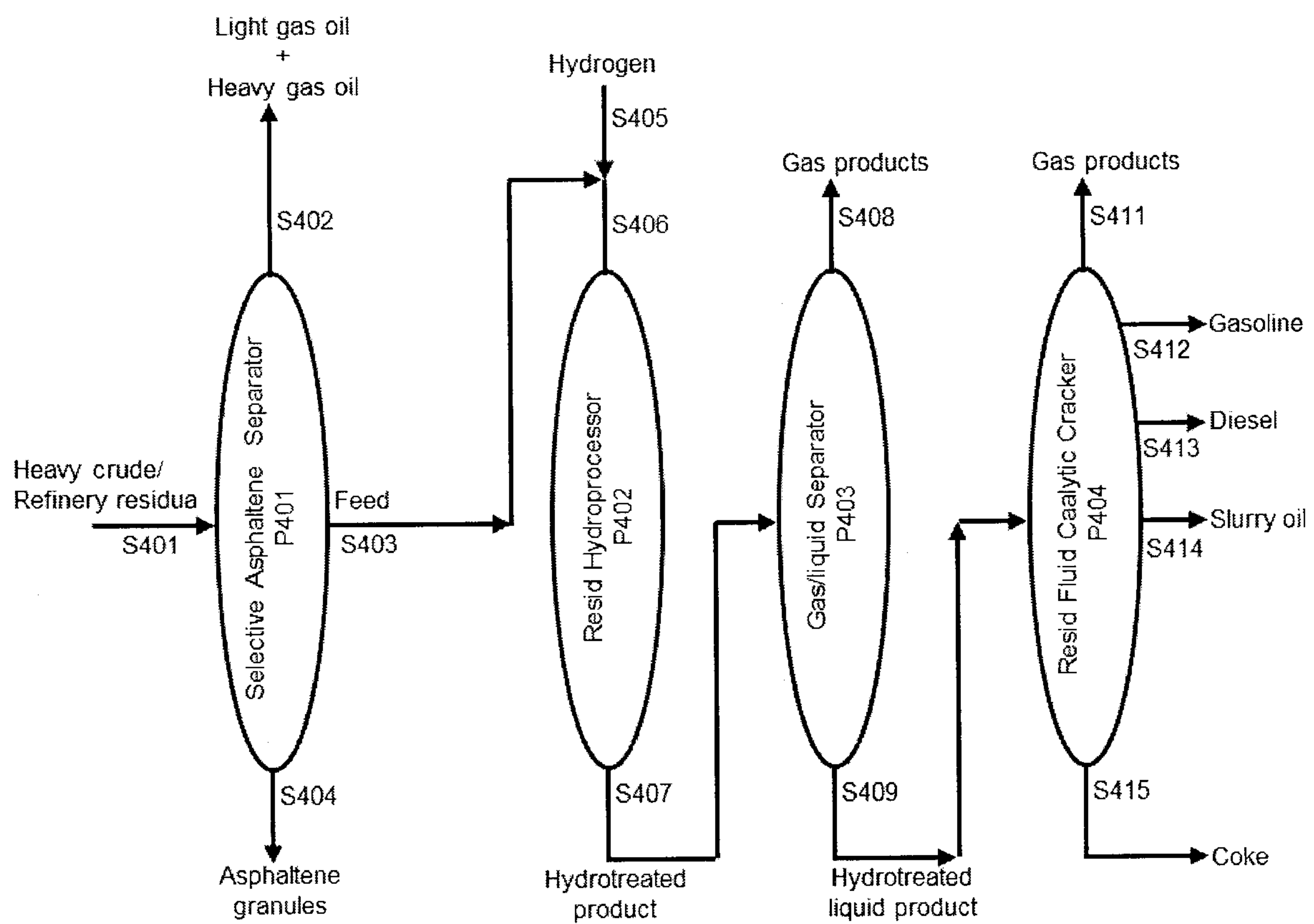
15. The process as claimed in any one of claims 1 to 14, wherein the contacting is effected while the feed is being flowed through the contacting zone in response to a driving force.

16. The process as claimed in any one of claims 1 to 15, further comprising deasphalting a heavy hydrocarbon-comprising material to generate the deasphalted heavy hydrocarbon-comprising material.

**Figure 1****Figure 2**

**Figure 3**

**Figure 4**

**Figure 5**

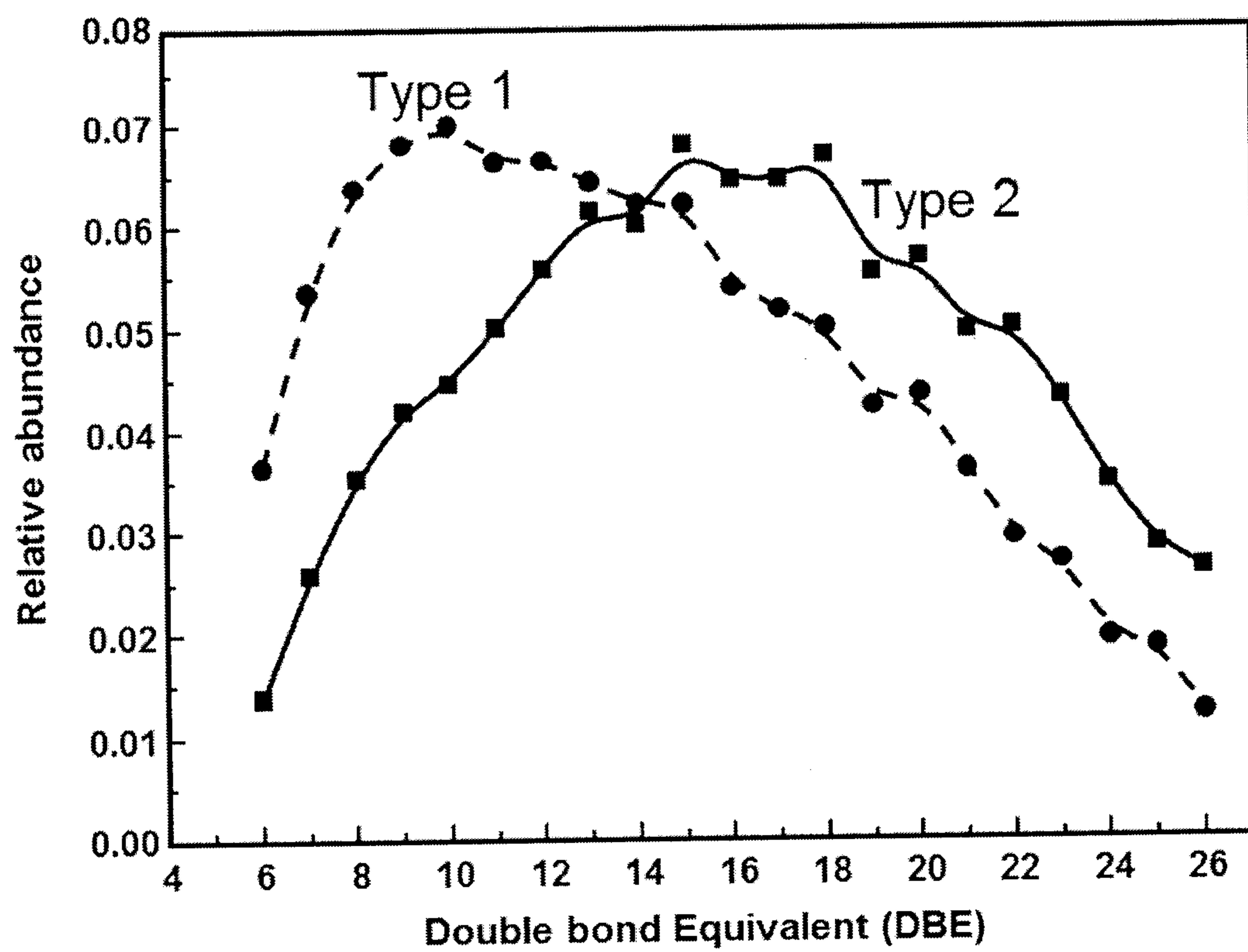


Figure 6