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Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

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(54) Title: A SUPPORTED CATALYST FOR SLURRY PHASE HYDROCRACKING OF REFINERY RESIDUE AND A PROCESS FOR ITS PREPARATION

(57) Abstract: The present disclosure relates to a catalyst for slurry phase hydrocracking of refinery residue 5 and a process for its preparation. The present disclosure provides a very simple method for exfoliation of metal sulphide, and a process of that provides effective slurry phase hydrocracking of refinery residue with a high yield.

A SUPPORTED CATALYST FOR SLURRY PHASE HYDROCRACKING OF REFINERY RESIDUE AND A PROCESS FOR ITS PREPARATION

FIELD

The present disclosure relates to a catalyst for slurry phase hydrocracking of refinery residue and a process for its preparation.

DEFINITIONS

As used in the present disclosure, the following words and phrases are generally intended to have the meaning as set forth below, except to the extent that the context in which they are used to indicate otherwise.

A sol composition: a sol composition is a colloidal suspension of very small solid particles in a continuous liquid medium. Sols are quite stable and exhibit the Tyndall effect. Artificial sols may be prepared by dispersion or condensation. Dispersion techniques include grinding solids to colloidal dimensions by ball milling and Bredig's arc method. The stability of sols may be maintained by using dispersing agents.

Triblock co-polymer: Block copolymers comprise two or more homopolymer subunits linked by covalent bonds. The union of the homopolymer subunits may require an intermediate non-repeating subunit, known as a junction block. Block copolymers with two or three distinct blocks are called diblock copolymers and triblock copolymers, respectively. Pluronic P123 is a type of triblock copolymer used in the method of this disclosure.

BACKGROUND

In refineries, petroleum feedstock is converted to valuable products, using different techniques. However, while converting the feedstock to valuable products, large quantity of residue is obtained. There is a need for the effective conversion of petroleum feedstock into desired petrochemical products and fuel feedstock with limited quantities of residue.

To limit residue production, different methods are employed like delayed coking, fluidized bed cracking, slurry phase hydrocracking for the up-gradation of refinery residue.

Hydrocracking of refinery residue requires high temperature, high pressure, and high hydrogen to oil ratio. Therefore, the conventional methods used for the hydrocracking may not be useful for residue up-gradation.

The use of catalyst-based systems for the cracking of the hydrocarbon feedstock is technically viable. However, the use of relatively expensive catalyst systems, catalyst deactivation, low quality of derived products and the need for catalyst recovery make these systems less viable for industrial applications.

Different catalytic systems are used for the effective conversion of petroleum feedstock. However, many conventional catalysts cannot withstand the severe reaction conditions.

Another major drawback of the prior art processes is that they do not exhibit sufficiently high conversions of refinery residue at very low residence time and low catalyst concentrations, to be of interest for industrial applications. In most cases the catalyst is costly or suffers deactivation due to severe reaction conditions.

There is, therefore, an evident necessity for further improvements in the process for conversion of refinery residue.

OBJECTS

Some of the objects of the present disclosure, which at least one embodiment herein satisfies, are as follows.

It is an object of the present disclosure to ameliorate one or more problems of the prior art or to at least provide a useful alternative.

An object of the present disclosure is to provide a catalyst for slurry phase hydrocracking of refinery residue.

Another object of the present disclosure is to provide a process for the preparation of a catalyst for slurry phase hydrocracking of refinery residue.

Still another object of the present disclosure is to provide a process for slurry phase hydrocracking of refinery residues in the presence of the catalyst of the present disclosure.

Other objects and advantages of the present disclosure will be more apparent from the following description, which is not intended to limit the scope of the present disclosure.

SUMMARY

In accordance with one aspect of the present disclosure there is provided a process for preparing a supported catalyst for slurry phase hydrocracking, the process comprises charging a vessel with a predetermined amount of metal sulphide and at least one fluid medium to obtain a first mixture; sonicating the first mixture to obtain an exfoliated product; mixing the exfoliated product with a predetermined amount of at least one support material to obtain a first slurry; heating the first slurry for a time period in the range of 12 to 60 hours at a temperature in the range of 10 to 80 °C to obtain a heated slurry; and drying and calcining the heated slurry under inert atmosphere to obtain the supported catalyst.

In accordance with the embodiments of the present disclosure, the metal sulphide comprises a metal selected from the group consisting of titanium, molybdenum, vanadium, chromium, manganese, iron, cobalt, nickel, zirconium, tungsten, ruthenium, rhodium, tin, tantalum, rhenium, and iridium.

In accordance with the embodiments of the present disclosure, the at least one support material is selected from the group consisting of pluronic P123, activated carbon, multiwall carbon nanotubes, γ-alumina, and porous silica.

In accordance with the embodiments of the present disclosure, the weight ratio of the amount of the metal sulphide and the at least one support material is in the range of 1:10 to 1:1000.

In accordance with the embodiments of the present disclosure, the calcination is carried out at a temperature in the range of 300 to 550 °C.

In accordance with another aspect of the present disclosure, there is provided a process for preparing a supported catalyst for slurry phase hydrocracking, the process comprises mixing a predetermined amount of at least one support material, a predetermined amount of at least one metal salt, and at least one fluid medium in a reactor at a temperature in the range of 10 to 80 °C to obtain a sol composition; ageing the sol composition to obtain an aged sol composition, followed by adding a predetermined amount of an acid to the aged sol composition and filtering to obtain a residue and a filtrate; drying and calcining the residue to obtain the supported catalyst for slurry phase hydrocracking.

In accordance with the embodiments of the present disclosure, the at least one support material is selected from the group consisting of pluronic P123, activated carbon, multiwall carbon nanotubes, γ-alumina, and porous silica.

In accordance with the embodiments of the present disclosure, the metal salt is selected from the group consisting of ammonium heptamolybdate, sodium molybdate, tungstic acid, and ammonium tungstate.

In accordance with the embodiments of the present disclosure, the weight ratio of the amount of the metal and the at least one support material is in the range of 1:20 to 1:1000.

In accordance with still another aspect of the present disclosure, there is provided a supported catalyst for slurry phase hydrocracking, which comprises an exfoliated product or a metal oxide supported on at least one support.

In accordance with still another aspect of the present disclosure, there is provided a process for slurry phase hydrocracking of the refinery residue using the supported catalyst, the process comprises charging a reactor with a predetermined amount of the supported catalyst and a predetermined amount of a refinery residue to obtain a mixture; introducing hydrogen gas in the reactor to attain a predetermined pressure to obtain a second mixture; and stirring the second mixture at a predetermined temperature for a predetermined time period to obtain the products.

In accordance with the embodiments of the present disclosure, the predetermined temperature is in the range of 200 to 500 °C

In accordance with the embodiments of the present disclosure, the weight ratio of the supported catalyst with respect to the refinery residue is in the range of 1: 100 to 1: 10000.

DETAILED DESCRIPTION

The present disclosure provides a metal based supported catalyst for slurry phase hydrocracking of refinery residue. The catalyst provides high yield during slurry phase hydrocracking process, thereby limiting the amount of residue. The catalyst of the present disclosure is an exfoliated metal sulphide or a metal oxide based catalyst supported on different support materials designed for slurry phase hydrocracking of refinery residue.

In accordance with one aspect of the present disclosure, there is provided a process for the preparation of a supported catalyst for slurry phase hydrocracking. The process comprises steps, which are described herein below.

A vessel is charged with a predetermined amount of a metal sulphide and at least one fluid medium to obtain a first mixture. The first mixture is exfoliated by sonicating it to obtain an exfoliated product. The exfoliated product is further mixed with a predetermined amount of at least one support material to obtain a slurry, which is then heated at a temperature in the range of 10 to 80 °C for a time period in the range of 12 to 60 hours to obtain a heated slurry. The heated slurry is dried and calcined under inert atmosphere to obtain the supported catalyst.

In accordance with the embodiments of the present disclosure, the metal sulphide comprises a metal selected from the group consisting of titanium, molybdenum, vanadium, chromium, manganese, iron, cobalt, nickel, zirconium, tungsten, ruthenium, rhodium, tin, tantalum, rhenium, and iridium.

In accordance with the embodiments of the present disclosure, the at least one support material is selected from the group consisting of activated carbon, multiwall carbon nanotubes, γ-alumina, and porous silica.

In accordance with the embodiments of the present disclosure, the weight ratio of the amount of the metal sulphide and the at least one support material is in the range of 1:10 to 1:1000.

In accordance with the embodiments of the present disclosure, the step of calcination is carried out at a temperature in the range of 200 to 550 °C.

In accordance with the embodiments of the present disclosure, the at least one fluid medium is selected from the group consisting of amines and alcohols.

In accordance with one embodiment of the present disclosure, the fluid medium is N-methyl pyrrolidone (NMP).

In accordance with another aspect of the present disclosure, there is provided a process for preparing the supported catalyst for slurry phase hydrocracking. The process comprises the steps, which are described herein below.

A sol composition is prepared by mixing a predetermined amount of at least one support material, a predetermined amount of at least one metal salt, and at least one fluid medium in a reactor at a temperature in the range of 10 to 80 °C. The so obtained sol composition is aged for a time period in the range of 3 to 15 hours to obtain an aged sol composition. A predetermined amount of an acid is added to the aged sol composition followed by filtering to obtain a residue and a filtrate. The residue is dried and calcined to obtain the supported catalyst for slurry phase hydrocracking.

In accordance with the embodiments of the present disclosure, the metal of the metal salt is at least one selected from a group consisting of titanium, vanadium, chromium, manganese, iron, cobalt, nickel, zirconium, niobium, molybdenum, tungsten, ruthenium, rhodium, tin, tantalum, rhenium and iridium.

The metal salt includes, but is not limited to, ammonium heptamolybdate, sodium molybdate, tungstic acid, tungsten sulphide, chromium sulphide, tin sulphide and ammonium tungstate. The metal salt used in the synthesis of the catalyst, acts as the source of the metal.

In accordance with one embodiment of the present disclosure, the metal salt is ammonium heptamolybdate.

In accordance with the embodiments of the present disclosure, the at least one support material is selected from the group consisting of Pluronic P123, activated carbon, multiwall carbon nanotubes, γ-alumina, and porous silica.

In accordance with the embodiments of the present disclosure, the weight ratio of the amount of the metal and the at least one support material is in the range of 1:20 to 1:1000.

In accordance with the embodiments of the present disclosure, the at least one fluid medium is selected from the group consisting of water, methanol, ethanol, and isopropanol.

In accordance with the embodiments of the present disclosure, the pH of the sol composition is maintained in the range of 1 to 3.

In accordance with still another aspect of the present disclosure, there is provided a supported catalyst for slurry phase hydrocracking. The supported catalyst of the present disclosure comprises an exfoliated metal sulphide or metal oxide supported on at least one support material.

In accordance with yet another aspect of the present disclosure there is provided a process for slurry phase hydrocracking of refinery residue. The process comprises the following steps:

a reactor is charged with a predetermined amount of a catalyst and a predetermined amount of a refinery residue to obtain a first mixture;

hydrogen gas is introduced in the reactor to attain a predetermined pressure to obtain a second mixture; and

the second mixture is stirred at a predetermined temperature for a predetermined time period to obtain the products.

The obtained products were analyzed using a refinery gas analyzer and High-Temperature Simulated Distillation.

The present disclosure is further described in light of the following experiments which are set forth for illustration purpose only and not to be construed for limiting the scope of the disclosure. The following experiments can be scaled up to industrial/commercial scale and the results obtained can be extrapolated to industrial scale.

Experiment 1: Preparation of MoS_2/C catalyst

0.2 g MoS_2 was mixed with 20 mL of N-Methyl-2-pyrrolidone (NMP) in a flask to obtain a mixture. The mixture was sonicated in water for 30 minutes, followed by probe sonication for 2 hours in an ice bath. The resultant solution was mixed with 2 g of an activated carbon. After stirring for 12 hours at room temperature, a gel was obtained, which was dried on rotary evaporator under reduced pressure.

The catalyst obtained was MoS_2/C with 6 wt% of Mo, 4 wt% of S and 90 wt% of C.

Experiment 2: Preparation of MoO_3 based supported catalyst

0.5 g of triblock copolymer P123 was charged in a reactor containing double distilled water to obtain a solution. The solution was vigorously stirred for 2 hours to obtain a homogenized solution. 10 g of ammonium heptamolybdate ($(NH_4)_6Mo_7O_{24}\bullet 4H_2O$, was added to the vigorously stirred solution to obtain a reaction mixture. The reaction mixture was aged for 8 hours to obtain an aged mixture. 1M HNO_3 was added to the aged mixture to maintain the pH of the aged mixture at 1.5. The reaction mixture was filtered to obtain a solid residue and a

filtrate. The solid residue was washed with ethanol and dried at 110 °C, for 24 hours, followed by calcination at 550 °C for 5 hours to obtain MoO_3 catalyst.

Experiment 3: Slurry phase hydrocracking using MoO_3 based catalyst

This experiment describes the slurry phase hydrocracking of residue in the presence of hydrogen using MoO_3 based catalyst.

0.125 g of MoO_3 and 250 g of a vacuum residue were taken in a batch reactor. The reactor was purged with nitrogen to remove any air trapped inside and later it was pressurized with Hydrogen to attain a pressure of 10 MPa. The reaction mixture was heated to 120 °C, under continuous stirring at 1000 rpm to obtain a slurry. The temperature was then increased to 420 °C. Heating was continued for 1 hour. After 1 hour the reaction was quenched by circulating chilled water to bring down the temperature below 300 °C. The gaseous products were collected in a gas bomb and were analyzed using gas chromatography. The liquid and solid samples were collected and analyzed in GC-SIMDIST as per ASTM D-7169.

The same experiment was conducted for two hours separately with the same reaction charge. The details of the analysis are provided in Table 1.

Table 1: Activity Tests using MoO_3 based catalyst

Reaction Time	Product Yield			Conversion of > 540 °C Cut
	Gas	Liquid	Solids	
1	11%	32%	57%	63%
2	13%	61%	26%	74%

It is observed that the residue fraction boiling above 540 ^{0}C in feed converted into lighter hydrocarbons and the conversion achieved is in the range of 63% and 74% for 1 hour and 2 hours reaction time respectively.

Experiment 4: Slurry phase hydrocracking using MoS_2/C as a catalyst

0.125g of MoS_2/C and 250 g of a vacuum residue were taken in a batch reactor. The reactor was purged with nitrogen to remove any air trapped inside and later was pressurized to 10 MPa with Hydrogen. The reaction mixture was heated to 120 °C under continuous stirring at 1000 rpm to obtain a slurry. The temperature was then increased to 420 °C. Heating was

continued for 1 hour. After 1 hour the reaction was quenched by circulating chilled water to bring down the temperature below 300 °C. The gaseous products were collected in a gas bomb and were analyzed using gas chromatography. The liquid and solid samples were collected and analyzed in GC-SIMDIST as per ASTM D-7169.

The results of this experiment are given in Table 2.

Table 2: Activity Tests using MoS_2/C Catalyst

Reaction Time	Product Yield			Conversion of > 540 ^{0}C Cut
	Gas	Liquid	Solids	
1	17%	46%	37%	63%

It was observed from experiment 4 that for a shorter residence time of 1 hour, the molybdenum based catalyst synthesized by impregnating on activated carbon gives a conversion of 63% at such very low concentration in the feed. A higher conversion with less solid make is envisaged at higher residence times and high catalyst concentration.

TECHNICAL ADVANCEMENTS

The present disclosure described herein above has several technical advantages including, but not limited to, the realization of:

- a supported catalyst for slurry phase hydrocracking of refinery residue; and
- a process that provides effective slurry phase hydrocracking of refinery residue with a high yield.

Throughout this specification the word “comprise”, or variations such as “comprises” or “comprising”, will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

The use of the expression “at least” or “at least one” suggests the use of one or more elements or ingredients or quantities, as the use may be in the embodiment of the invention to achieve one or more of the desired objects or results. While certain embodiments of the inventions have been described, these embodiments have been presented by way of example only, and

are not intended to limit the scope of the inventions. Variations or modifications to the formulation of this invention, within the scope of the invention, may occur to those skilled in the art upon reviewing the disclosure herein. Such variations or modifications are well within the spirit of this invention.

The numerical values given for various physical parameters, dimensions and quantities are only approximate values and it is envisaged that the values higher than the numerical value assigned to the physical parameters, dimensions and quantities fall within the scope of the invention unless there is a statement in the specification to the contrary.

While considerable emphasis has been placed herein on the specific features of the preferred embodiment, it will be appreciated that many additional features can be added and that many changes can be made in the preferred embodiment without departing from the principles of the disclosure. These and other changes in the preferred embodiment of the disclosure will be apparent to those skilled in the art from the disclosure herein, whereby it is to be distinctly understood that the foregoing descriptive matter is to be interpreted merely as illustrative of the disclosure and not as a limitation.

CLAIMS:

1. A process for preparing a supported catalyst for slurry phase hydrocracking, said process comprising the following steps:

   i. charging a vessel with a predetermined amount of metal sulphide and at least one fluid medium to obtain a first mixture;

   ii. sonicating/exfoliating said first mixture to obtain an exfoliated product;

   iii. mixing said exfoliated product with a predetermined amount of at least one support material to obtain a slurry;

   iv. heating said slurry for a time period in the range of 12 to 60 hours at a temperature in the range of 10 to 80 °C to obtain a heated slurry; and

   v. drying and calcining said heated slurry under inert atmosphere to obtain the supported catalyst.

2. The process as claimed in claim 1, wherein said metal sulphide comprises a metal selected from the group consisting of titanium, molybdenum, vanadium, chromium, manganese, iron, cobalt, nickel, zirconium, tungsten, ruthenium, rhodium, tin, tantalum, rhenium, and iridium.

3. The process as claimed in claim 1, wherein said at least one support material is selected from the group consisting of activated carbon, multiwall carbon nanotubes, γ-alumina, and porous silica.

4. The process as claimed in claim 1, wherein the weight ratio of the amount of said metal sulphide and said at least one support material is in the range of 1:10 to 1:1000.

5. The process as claimed in claim 1, wherein said calcination is carried out at a temperature in the range of 300 to 550 °C.

6. A process for preparing a supported catalyst for slurry phase hydrocracking, said process comprising the following steps:

   a. mixing a predetermined amount of at least one support material, a predetermined amount of at least one metal salt, and at least one fluid medium in a reactor at a temperature in the range of 10 to 80 °C to obtain a sol composition;

b. ageing said sol composition to obtain an aged sol composition, followed by adding a predetermined amount of an acid to said aged sol composition and filtering to obtain a residue and a filtrate;

c. drying and calcining said residue to obtain the supported catalyst for slurry phase hydrocracking.

7. The process as claimed in claim 6, wherein said at least one support material is selected from the group consisting of pluronic P123, activated carbon, multiwall carbon nanotubes, γ-alumina, and porous silica.

8. The process as claimed in claim 6, wherein the metal salt comprises a metal selected from the group consisting of titanium, molybdenum, vanadium, chromium, manganese, iron, cobalt, nickel, zirconium, tungsten, ruthenium, rhodium, tin, tantalum, rhenium, and iridium.

9. The process as claimed in claim 6, wherein said metal salt is selected from the group consisting of ammonium heptamolybdate, sodium molybdate, tungstic acid, and ammonium tungstate.

10. The process as claimed in claim 6, wherein the weight ratio of the amount of said metal and said at least one support material is in the range of 1:20 to 1:1000.

11. A supported catalyst for slurry phase hydrocracking comprising an exfoliated metal sulphide or metal oxide supported on at least one support.

12. The supported catalyst as claimed in claim 11, wherein said metal sulphide or said metal oxide comprises a metal selected from the group comprising titanium, molybdenum, vanadium, chromium, manganese, iron, cobalt, nickel, zirconium, tungsten, ruthenium, rhodium, tin, tantalum, rhenium, and iridium.

13. A process for slurry phase hydrocracking of the refinery residue using the supported catalyst as claimed in claim 1 or 6; said process comprising the following steps:

a. charging a reactor with a predetermined amount of said supported catalyst and a predetermined amount of a refinery residue to obtain a mixture;

b. introducing hydrogen gas in said reactor to attain a predetermined pressure to obtain a second mixture; and

c. stirring said second mixture at a predetermined temperature for a predetermined time period to obtain the products.

14. The process as claimed in claim 13, wherein said predetermined temperature is in the range of 200 to 500 °C

15. The process as claimed in claim 13, wherein the weight ratio of said supported catalyst with respect to the refinery residue is in the range of 1: 100 to 1: 10000.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2016/053618

A. CLASSIFICATION OF SUBJECT MATTER
C10G47/00 Version=2016.01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C10G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Patseer, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US6902664 B2 (Hye Kyung C. Timken)(2005-07-06) 7 June 2005 Column 10, para[51-65]; column 13-14, examples 4-5	6
Y	US20150129463 A1 (Mahshad Alaei ;Alimorad Rashidi ;Alireza Mahjoub;Mohsen Ghanami ;Amir Hossein Bornaee) 2015.14.05 (14 may 2015) Page 3, para[0042],[0046] .Page 4,para [0054] example 3	1-5 and 7-15

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29-08-2016	29-08-2016

Name and mailing address of the ISA/	Authorized officer
Indian Patent Office Plot No.32, Sector 14,Dwarka,New Delhi-110075	Latika Dawara
Facsimile No.	Telephone No. +91-1125300200

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2016/053618

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
The International Searching Authority found Two (groups of) inventions in this application, as follows: Group I: claims: 1-5 and 11-15 partially: Process for preparing a supported catalyst for slurry phase hydrocracking using sonicating/exfoliating technique ; supported catalyst for slurry phase hydrocracking and process for slurry phase hydrocracking of the refinery residue using the supported catalyst.
Group II: Claims 6-10 and 11-15 partially; Process for preparing a supported catalyst for slurry phase hydrocracking using sol composition; Supported catalyst for slurry phase hydrocracking and

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

International application No.
PCT/IB2016/053618

Continuation of Observations where unity of invention is lacking(Box III)

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process for slurry phase hydrocracking of the refinery residue using the supported catalyst.

Lack of unity of invention in the claims of the present application is directly evident "a priori" since the claims are related to two distinct processes which are not so linked as to form a single general inventive concept under PCT Rule 13.1.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2016/053618

Citation	Pub.Date	Family	Pub.Date
US 6902664 B2	07-06-2005	AU 2003284044 A1	03-06-2004
		CN 1723265 A	18-01-2006
		EP 1560898 A1	08-10-2005