

FILED ELECTRONICALLY

PATENT APPLICATION
Docket No. 15913.730.1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:		)
	David M. Mountainland	)
Serial No.:	15/258,706	) Art Unit
		) 1771
Filed:	09/07/2016	)
Confirmation No.:	3568	)
For:	UPGRADED EBULLATED BED REACTOR USED WITH OPPORTUNITY FEEDSTOCKS	)
		)
Examiner:	Michelle Stein	)
		)
Customer No.:	022913	)

**DECLARATION OF DAVID M. MOUNTAINLAND, BRETT M. SILVERMAN
AND MICHAEL A. RUETER UNDER 37 C.F.R. § 1.132**

We, David M. Mountainland, Brett M. Silverman, and Michael A. Rueter, hereby declare as follows

1. We are citizens of the United States of America and reside at 23 Southern Way, Princeton, New Jersey 08540; 2568 East 3020 South, Salt Lake City, Utah 84109; and 350 Maiden Lane, Plymouth Meeting, Pennsylvania 19462, respectively.

2. I, David M. Mountainland, received a Bachelor of Science degree in Chemical Engineering from Drexel University in 1986 and am a member of the National Petroleum Refiners Association and the American Institute of Chemical Engineers.

3. From 2000 to the present I, David M. Mountainland, have been employed by and have worked at a research facility owned by Hydrocarbon Technology & Innovation, LLC and its predecessors (collectively "HTI"), which is the Assignee of U.S. Patent Application No. 15/258,653, filed September 7, 2016 ("Application"), and perform research and development in the field of heavy oil and heavy oil upgrading, including hydrocracking and other processes used in converting heavy oil. Between 1986-2000 I was employed by various companies in the field of heavy oil upgrading and other aspects of petroleum refining.

4. While at HTI, I have been responsible for implementing heavy oil upgrading technology at five commercial refineries and providing technical support to the refinery operators. I also provide technical and marketing support for future heavy oil upgrading technology licensees. In addition, I perform process simulations, kinetic modeling, and commercial process economic evaluations as required.

5. I, Brett M. Silverman, received a Bachelor of Science degree in Chemistry from Old Dominion University in 2000, a Master of Arts from Princeton University in 2002, and a Ph.D. in Chemistry from Princeton University in 2005.

6. From 2005 to the present I, Brett M. Silverman, have been employed by and have worked at a research facility owned by HTI, and perform research and development in the fields of catalysis, heavy oil and heavy oil upgrading, including hydrocracking and other processes used in converting heavy oil. During my employment at HTI, I have been responsible for implementing heavy oil upgrading technology at five commercial refineries and providing technical support to the refinery operators. I also provide technical and marketing support for future heavy oil upgrading technology licensees. In addition, I have expertise in organometallic catalysis, heavy oil characterization, refinery fouling analysis, and commercial process economic evaluations as required.

7. I, Michael A. Rueter, received a B.S. degree in Chemical Engineering from Carnegie-Mellon University in 1988, an M.S. degree in Chemical Engineering from the University of Pennsylvania in 1990, and a Ph.D. degree in Chemical Engineering from the University of Pennsylvania in 1993.

8. From 1999 to the present I, Michael A. Rueter, have been employed by and have worked at a research facility owned by HTI, and perform research and development in the field of heavy oil and heavy oil upgrading, including hydrocracking and other processes used in converting heavy oil. During my employment at HTI, I have conducted laboratory and pilot plant research related to heavy oil upgrading, homogeneous and heterogeneous catalysis, and related fields. I have expertise in all aspects of process research and development, as well as process modelling and economic evaluation.

9. We are therefore skilled in the art of heavy oil upgrading and are knowledgeable about the invention disclosed and claimed in the Application.

10. We reviewed the Office Action dated March 8, 2019 ("Office Action"), in which claims 1-22 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Bhattacharya et al. (US 5,372,705) ("Bhattacharya") alone or alternatively in view of Lott et al. (US 2005/0241991) ("Lott").

11. We reviewed Bhattacharya and Lott and are knowledgeable about their respective teachings. We cannot find any teaching or suggestion in Bhattacharya and Lott for a process of upgrading an ebullated bed reactor that includes two different steps or phases of operation: (1) an initial step or phase of operating an ebullated bed at initial conditions, including (i) hydroprocessing a heavy oil feedstock of initial quality, (ii) using a heterogeneous catalyst without a dispersed metal sulfide catalyst, and (iii) operating at an initial reactor severity and rate of production of converted products; and (2) a second step or phase of operating an upgraded

ebullated bed reactor, including (i) hydroprocessing a lower quality heavy oil feedstock or feedstock blend, (ii) using of a dual catalyst system comprised of a dispersed metal sulfide catalyst and heterogeneous catalyst, and (iii) operating at conditions that maintain a reactor severity and rate of production of converted products at least as high as the initial reactor severity and rate of production of converted products.

12. The independent claims as amended define the quality of the heavy oil feedstock as its "sediment forming tendency", wherein a lower quality heavy oil feedstock has higher sediment forming tendency and a higher quality heavy oil feedstock has lower sediment forming tendency. In general, a heavy oil feedstock having higher sediment forming tendency will increase the rate of equipment fouling than a heavy oil feedstock having lower sediment forming tendency.

13. Although the sediment forming tendency of a heavy oil feedstock is not always quantifiable, those skilled in the art of heavy oil upgrading know which heavy oil feedstocks have lesser or greater sediment forming tendencies. All crude oils have a vacuum resid component that has a characteristic sediment forming tendency. For example, Eastern European crude oils such as Ural, South American crude oils such as Venezuelan and Colombian, and some Central or North American crude oils such as Mexican and certain Gulf of Mexico crudes have vacuum resid components that have significantly higher sediment forming tendency compared to ordinary crudes, such as West Texas Intermediate crude oil, Alaska North Slope crude oil, many African crude oils, North Sea crude oils, and most Middle Eastern crude oils including Arabian Medium Crude, Arabian Heavy Crude, and Bonny Light Crude.

14. Because of the greater sediment forming tendency of their derived vacuum residues, crude oils such as Ural, South American, Mexican, and other crudes listed above are harder to hydroprocess, are less expensive than ordinary crudes, and are therefore examples of

“opportunity crudes” for which the derived vacuum residue can be advantageously hydroprocessed using an upgraded ebullated bed reactor according to the inventive method while maintaining a reactor severity and rate of production of converted products at least as high as when hydroprocessing an initial heavy oil feedstock of higher quality (lower sediment forming tendency) at initial conditions using a heterogeneous catalyst.

15. Bhattacharya does not disclose or suggest the use of opportunity crudes characterized as containing a vacuum resid component having high sediment forming tendency. Rather, Bhattacharya discloses the use of either a blend of vacuum resid fractions from Alaska North Slope Crude, Arabian Medium Crude, Arabian Heavy Crude, and Bonny Light Crude (col. 3, lines 53-58) or an Arab Medium vacuum resid (col. 3, lines 59-61), none of which has particularly high sediment forming tendency. The blend of vacuum resid fractions from Alaska North Slope Crude, Arabian Medium Crude, Arabian Heavy Crude, and Bonny Light Crude appears to have slightly lower sediment forming tendency than that of Arab Medium vacuum resid according to the data in the table at col. 3, line 63 to col. 4, line 17 of Bhattacharya. Therefore, the blend of vacuum resid fractions in Bhattacharya does not constitute a *lower quality feedstock blend* compared to the Arab Medium vacuum resid used in Examples I-VII.

16. Examples I-VII in Bhattacharya all used the same heavy oil feedstock—“Arab Medium vacuum resid” (col. 9, line 10; col 11, lines 18-19). The heavy cycle gas oil (HCGO) added to the Arab Medium vacuum resid in Examples VI-VII is objectively *not* a heavy oil feedstock having “greater sediment forming tendency” than the Arab Medium vacuum resid. According to Bhattacharya, the use of HCGO is the key inventive feature that *reduces* “insolubles formation” and improves “ease of operation” when using a dual catalyst system rather than a heterogeneous catalyst by itself (col. 11, lines 16-33). HCGO is therefore not a

lower quality heavy oil feedstock relative to the Arab Medium vacuum resid. Nor does adding HCGO to the Arab Medium vacuum resid form a lower quality feedstock blend.

17. In summary, Bhattacharya does not disclose or suggest a method that includes initially hydroprocessing a higher quality heavy oil feedstock using a heterogeneous catalyst at initial conditions, including an initial reactor severity and rate of production of converted products, and then hydroprocessing a lower quality heavy oil feedstock and/or lower quality feedstock blend having greater sediment forming tendency, using a dual catalyst system, and at a reactor severity and rate of production of converted products at least as high as when operating the ebullated bed reactor at the initial conditions.

18. Lott also does not disclose or suggest a method that includes initially hydroprocessing a higher quality heavy oil feedstock using a heterogeneous catalyst at initial conditions, including an initial reactor severity and rate of production of converted products, and then hydroprocessing a lower quality heavy oil feedstock and/or lower quality feedstock blend having greater sediment forming tendency, using a dual catalyst system, and at a reactor severity and rate of production of converted products at least as high as when operating the ebullated bed reactor at the initial conditions.

19. One measure of “reactor severity” is the operating temperature of the ebullated bed reactor. Another is the throughput. Lott teaches that “the temperature required to effect hydrocracking may vary depending on the properties and chemical make up of the heavy oil feedstock” (paragraph [0081]). Lott further teaches that “[m]ilder reactor temperature and longer feedstock Space Velocity are typically required for heavy oil feedstock with high reactivity and/or high concentration of asphaltenes.” (*id.*). Because high reactivity and high asphaltene concentration are objectively correlated with higher sediment forming tendency, Lott is objectively understood as teaching that reactor severity should be *decreased* when

hydroprocessing a heavy oil feedstock having greater sediment forming tendency, both in terms of reduced temperature and reduced throughput.

20. The Examples in the Application demonstrate how to upgrade an ebullated bed reactor to hydroprocess a lower quality heavy oil feedstock while maintaining the same or higher reactor severity and rate of production of converted products. Examples 1 and 2 show comparative reactor conditions and results of an ebullated bed while using only a heterogeneous catalyst. Example 3 shows reactor conditions and results when using a dual catalyst system comprising a heterogeneous catalyst and a dispersed metal sulfide catalyst to hydroprocesses a lower quality feedstock blend.

21. In comparative Example 2, the use of a lower quality feedstock blend containing 80% Arab Medium vacuum resid and 20% Ural vacuum resid (derived from Ural Crude, an opportunity crude oil) resulted in slightly higher resid conversion, slightly higher C₇ asphaltene conversion, and higher MCR conversion, but at the cost of a nearly 50% increase in the production of equipment fouling sediment (both separator bottoms basis and feed oil basis).

22. In Example 3, by contrast, the use of a dual catalyst system to hydroprocess the same lower quality feedstock blend of 80% Arab Medium vacuum resid and 20% Ural vacuum resid used in comparative Example 2 resulted in essentially the same resid conversion, a 12% increase in C₇ asphaltene conversion, and a 12% increase of MCR conversion compared to Example 1. However, rather than increasing the production of equipment forming sediment by nearly 50% as in comparative Example 2, the use of the dual catalyst system resulted in a 70% *decrease* in the production of equipment fouling sediment (both separator bottoms basis and feed oil basis).

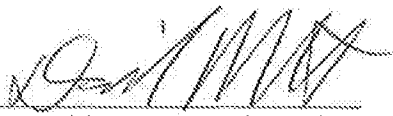
23. Example 5 also shows that using a dual catalyst system instead of a heterogeneous catalyst as in comparative Example 4 resulted in a dramatic decrease in the production of

equipment fouling sediment when hydroprocessing a lower quality feedstock blend containing 80% SEG-17 (Middle Eastern heavy oil feedstock) and 20% Ural vacuum resid. In Example 5, which used a dual catalyst system, the residue conversion was the same but the C₇ asphaltene conversion increased by nearly 22%, sediment formation decreased by 80%, VTB Gravity was increased by nearly 3.9 °API, desulfurization increased by more than 2%, VTB viscosity decreased by 234 cPs at 300°C, and CCR conversion increased by 15% compared to Example 4.

24. In summary, Examples 3 and 5 demonstrate how an ebullated bed reactor can be upgraded to utilize a dual catalyst system in order to efficiently utilize an opportunity crude that yields a lower quality heavy oil feedstock and/or lower quality feedstock blend while maintaining reactor severity and rate of converted products at least as high as when operating the ebullated bed reactor at initial conditions to hydroprocess an initial higher quality feedstock using only a heterogeneous catalyst.

We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made may be punishable by fine or imprisonment, or both, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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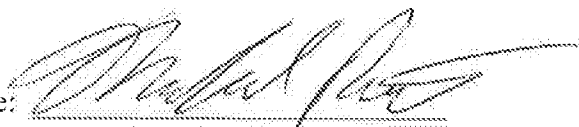
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