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[Continued on next page]

(54) Title: MATERIALS AND METHODS FOR IMPROVING SELECTIVITY IN HETEROGENEOUS CATALYSTS AND PRODUCTS THEREOF

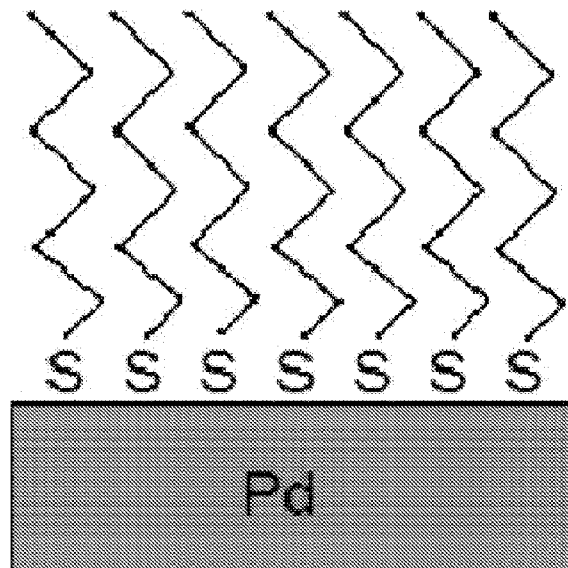


Fig. 1

(57) Abstract: Methods for improving selectivity in heterogeneous catalysts, and products thereof, are disclosed. In exemplary embodiments, multifunctional oxygenates may be selectively converted to value-added products through reaction at a single functional position. Addition of a self-assembled monolayer (SAM), or SAM-like structures to a supported metal catalyst is also disclosed.



DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT,
LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE,
SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA,
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24 April 2014

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/023520

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B01J 23/00 (2012.01)

USPC - 502/300

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)

IPC(8) - B01J 23/00; B01J 23/44 (2012.01)

USPC - 502/222, 223, 251, 258, 261, 262, 300, 313, 333; 585/660, 661

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)

Patbase, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	YU et al. The Structure of Atomic Sulfur Phases on Au(111). J. Phys. Chem. 2007, Vol. 111, pp.10904-10914. 29 June 2007 (29.06.2007) entire document	1-5, 9-17
A	US 7,125,820 B2 (CAMPBELL) 24 October 2006 (24.10.2006) entire document	1-5, 9-17
A	US 5,254,788 A (GARTSIDE et al) 19 October 1993 (19.10.1993) entire document	1-5, 9-17
A	US 2008/0227629 A1 (CHIGAPOV et al) 18 September 2008 (18.09.2008) entire document	1-5, 9-17
A	US 2006/0217263 A1 (KAWAMOTO et al) 28 September 2006 (28.09.2006) entire document	1-5, 9-17

☐ Further documents are listed in the continuation of Box C.


* 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

27 June 2012

Date of mailing of the international search report

13 JUL 2012

Name and mailing address of the ISA/US

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2012/023520

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:

(see Extra Sheet)

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.:
1-5, 9-17

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.

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I, claims 1-5 and 9-17 (in part) are drawn to a metal catalyst having a specific geometrical configuration.

Group II, claims 6-8, 9-17 (in part), and 37-73 are drawn to a method for using a coated metal catalyst with a feedstock.

Group III, claims 18-36 are drawn to a supported metal catalyst having a carbon-carbon bond selectivity rate.

Claims 9-17 are multiple dependent claims depending from either of claims 1 or 6.

The inventions listed in Groups I, II and III do not relate to a single general inventive concept under PCT Rule 13.1, because under PCT Rule 13.2 they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I, a metal catalyst of selenium and/or sulfur wherein at least 70% of the compound(s) is in the $(^{1/3} \times ^{1/3})R_{30}$ geometry, are not present in Groups II or III; the special technical features of Group II, a method for producing a selective catalyst by providing a supported metal catalyst including coating with a molecule comprising a hydrocarbon tail, are not present in Groups I or III; and the special technical features of Group III, a supported metal catalyst for selectively reducing a carbon-carbon bond wherein selectivity is at a yield of at least 60%, are not present in Groups I or II.

Groups I through III share the technical features of a supported metal catalyst wherein the catalyst comprises a selenide. However, these shared technical features do not represent a contribution over the prior art.

Specifically, US 2004/0024274 A1 to Bottcher et al. teach a process for the hydrogenation of a monocyclic or polycyclic aromatic which may be unsubstituted or substituted by at least one alkyl group comprises bringing the aromatic into contact with a hydrogen-containing gas in the presence of a catalyst comprising at least one metal of transition group VIII of the Periodic Table as active metal applied to a structured or monolithic support (Abstract) wherein the catalyst comprises selenium (Paras. [0031] and [0036] catalysts used for the purposes of the present invention may further comprise...selenium) and wherein selective hydrogenation occurs at a high yield (Para. [0061] the aromatic compounds can be hydrogenated in an economical manner, selectively and in a high space-time yield...; see also Para. [0074]).

Since none of the special technical features of the Group I, II, and III inventions are found in more than one of the inventions, unity is lacking.