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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Declarations under Rule 4.17:

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

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:
3 December 2009

(54) Title: CATALYST COMPOSITIONS AND METHODS FOR ALCOHOL PRODUCTION FROM SYNTHESIS GAS

(57) Abstract: In one aspect of this invention, catalytic compositions produced by calcining intermediates of the formula $[NR_4]_X[M^1M^2S_8]$ are provided, wherein M^1 is Mo or W; M^2 is Co, Ni, or Pd; x is 2 or 3; and R is a C_3-C_8 alkyl group. Another aspect provides catalytic compositions produced by calcining intermediates of the formula $A_x[M^1M^2S_8]$, wherein A is selected from K, Rb, Cs, Sr, and Ba. Also provided are methods for making the compositions, and methods of using the compositions for the catalytic conversion of syngas into C_1-C_4 alcohols such as ethanol.

WO 2009/079267 A3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2008/086019

A. CLASSIFICATION OF SUBJECT MATTER

C07F 11/00(2006.01)i, C07F 15/00(2006.01)i, C07F 15/04(2006.01)i, C07F 15/06(2006.01)i, B01J 23/88(2006.01)i, B01J 23/882(2006.01)i, B01J 23/888(2006.01)i

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: C07F

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)

e-KOMPASS (KIPO internal)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2006/0009537 A1 (COCA IORDACHE-CAZANA et al.) 12 January 2006 See examples and claims	1-94
A	US 2003/0158270 A1 (DEVINDER MAHAJAN) 21 August 2003 See examples and claims	1-94
A	US 4,476,247 A (FREDERICK A. PESA et al.) 09 October 1984 See examples and claims	1-94
A	US 4,513,100 A (VITTORIO FATTORE et al.) 23 April 1985 See examples and claims	1-94
A	US 4,609,678 A (HARLEY F. HARDMAN et al.) 02 September 1986 See examples and claims	1-94

☐ 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 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
14 OCTOBER 2009 (14.10.2009)	**14 OCTOBER 2009 (14.10.2009)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer JEONG, Sei Joon Telephone No. 82-42-481-8270

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2008/086019

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:

Group I: A compound of the formula [NR4]x[M12M2S8], wherein M1 is Mo or W; M2 is Co, Ni, or Pd (Claims 1-20, 28-38, 47-58 (partially), 59-84, 93-94 (partially))

Group II: A compound of the formula Ax[M12M2S8], wherein A is selected from the group consisting of K, Rb, Cs; M1 is Mo or W; M2 is Co, Ni, or Pd (Claims 21, 23, 25-27 (partially), 39-58 (partially), 85, 87-94 (partially))

Group III: A compound of the formula Ax[M12M2S8], wherein A is selected from the group consisting of Sr and Ba; M1 is Mo or W; M2 is Co, Ni, or Pd (Claims 22, 24, 25-27(partially), 39-58(partially), 86, 87-94(partially))

1. ☒ As all required addtional 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 an additional fee, this Authority did not invite payment of any additional fee.

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 SEARCH REPORT

Information on patent family members

International application No.

PCT/US2008/086019

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