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[Continued on next page]

(54) Title: CATALYSTS FOR OXIDATIVE COUPLING OF METHANE

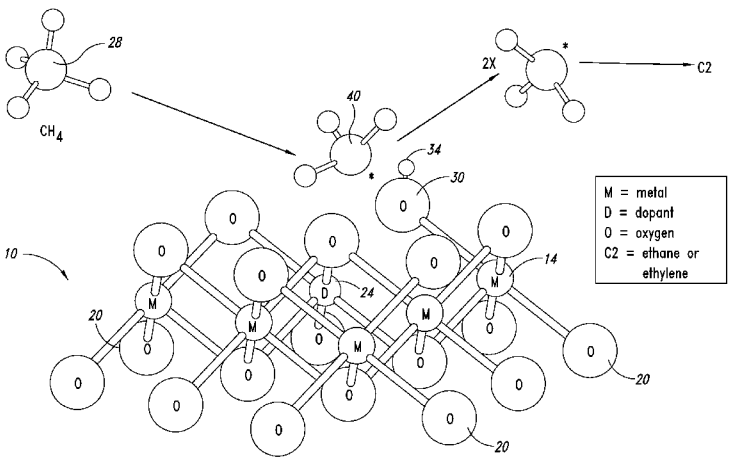


FIG. 1

(57) Abstract: Metal oxide catalysts comprising various dopants are provided. The catalysts are useful as heterogenous catalysts in a variety of catalytic reactions, for example, the oxidative coupling of methane to C2 hydrocarbons such as ethane and ethylene. Related methods for use and manufacture of the same are also disclosed.

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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, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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))*

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INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. B01J23/00 B01J23/02 B01J23/10 B01J23/34 B01J23/38
B01J23/76 B01J23/54 C07C2/84 B01J21/02 B01J21/10
B01J23/30

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)
B01J C07C

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2011/149996 A2 (SILURIA TECHNOLOGIES INC [US]; SCHER ERIK C [US]; ZURCHER FABIO R [US]) 1 December 2011 (2011-12-01) the whole document more particularly: page 23, lines 1-14 page 34, lines 21-28 page 99, line 21 - page 100, line 17 page 52, lines 17-22 page 101, line 1 - page 102, line 22 page 38, line 14 - page 39, line 24 page 133, line 15 - page 140, line 3 page 156, line 1 - page 159, line 13 ----- -/--	1-85

[X] Further documents are listed in the continuation of Box C.

[X] 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
16 August 2012	18/01/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Gosselin, Daniel

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/039383

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 additional 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 an 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.:

1-6(completely); 63-75, 81-85(partially)

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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6(completely); 63-75, 81-85(partially)

   mixed oxide of magnesium and manganese wherein are further comprised lithium and boron dopants and at least one doping element from groups 4, 9, 12, 13 and combinations thereof, use thereof as catalyst in oxidative coupling of methane

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2. claims: 7, 9, 39, 40(completely); 63-75, 81-85(partially)

   mixed oxide of manganese and tungsten, wherein are further comprised sodium dopant and at least one doping element from groups 2 and 16 and combinations thereof, or 2, 4-6, 8-15, lanthanides and combinations thereof, and use thereof as catalyst in oxidative coupling of methane

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3. claims: 10-38, 44-50, 57-62(completely); 63-75, 81-85(partially)

   oxide of rare earth element, which further comprises at least one doping element selected from groups 1-16, lanthanides, actinides or combinations thereof, the dopants forming not necessarily a mixed oxide with the rare earth oxide, and use thereof as catalyst in oxidative coupling of methane

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4. claims: 41-43(completely); 63-75, 81-85(partially)

   mixed oxide of lanthanide and tungsten, which further comprises sodium and at least one doping element selected from groups 2, 4-15, lanthanides or combinations thereof, and use thereof as catalyst in oxidative coupling of methane

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5. claims: 51-55(completely); 63-75, 81-85(partially)

   mixed oxide of rare earth element and a group 13 element (B, Al, Ga, In, Tl), which further comprises one or more group 2 elements, and use thereof as catalyst in oxidative coupling of methane

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6. claims: 76-80

   Method for the preparation of downstream product of ethylene , wherein the ethylene is defined as product-by-process

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/039383

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CHRISTIAN ENGER B ET AL: "A review of catalytic partial oxidation of methane to synthesis gas with emphasis on reaction mechanisms over transition metal catalysts", APPLIED CATALYSIS A: GENERAL, ELSEVIER SCIENCE, AMSTERDAM, NL, vol. 346, no. 1-2, 31 August 2008 (2008-08-31), pages 1-27, XP022939916, ISSN: 0926-860X, DOI: 10.1016/J.APCATA.2008.05.018 [retrieved on 2008-05-21] the whole document more particularly: page 13, left hand column, thrid full paragraph -----	1-6, 63-75, 81-85
A	EP 0 253 522 A2 (ATLANTIC RICHFIELD CO [US]) 20 January 1988 (1988-01-20) the whole document page 4, line 53 - page 5, line 26 page 7, lines 3-5 page 8, lines 17-57 example 5 -----	1-85

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/039383

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WO 2011149996 A2	01-12-2011	US 2012041246 A1	16-02-2012
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