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(54) Title: COMPOSITE PROTON CONDUCTING MEMBRANE WITH LOW DEGRADATION AND MEMBRANE ELECTRODE ASSEMBLY FOR FUEL CELLS INCLUDING THE SAME

(57) Abstract: A small molecule or polymer additive can be used in preparation of a membrane electrode assembly to improve its durability and performance under low relative humidity in a fuel cell. Specifically, a method of forming a membrane electrode assembly comprising a proton exchange membrane, comprises providing an additive comprising at least two nitrogen atoms to the membrane electrode assembly.



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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER INV. H01M8/10 B01D67/00 B01D71/06 C08J5/22 ADD.		
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) H01M B01D C08J		
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 practical, search terms used) EPO-Internal, WPI Data, INSPEC, COMPENDEX		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A X A	US 2005/136308 A1 (BALLARD POWER SYSTEMS, INC.; BDF IP HOLDINGS, LTD.) 23 June 2005 (2005-06-23) paragraph [0011] - paragraph [0020] paragraph [0035] claims 1,17,18,24,26 ----- JP 2008 288097 A (HONDA MOTOR CO., LTD.) 27 November 2008 (2008-11-27) abstract ----- <div style="text-align: center;">-/-</div>	1-3,7,8, 10-13, 20,21 4-6,9, 14-19, 22,23 1-3,7, 9-13,20, 21 4-6,8, 14-19, 22,23
<div style="display: flex; justify-content: space-between;"> ☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex. </div>		
* Special categories of cited documents : <div style="display: flex;"> <div style="flex: 1;"> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="flex: 1;"> <p>"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</p> <p>"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</p> <p>"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.</p> <p>"&" document member of the same patent family</p> </div> </div>		
Date of the actual completion of the international search	Date of mailing of the international search report	
28 April 2011	09/05/2011	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Masson, Jean-Pierre	

INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	WO 2007/144633 A1 (JOHNSON MATTHEY PLC; UNIVERSITY OF READING) 21 December 2007 (2007-12-21) page 1, line 25 - page 2, line 15 page 5, lines 10-20 page 5, line 30 - page 6, line 11 page 7, lines 16-18 page 8, lines 5-8 claims 1,4,5,7,9,10,12 -----	1,2,7, 9-13,15, 17,20,21 3-6,8, 14,16, 18,19, 22,23
X A	US 2006/083976 A1 (CALIFORNIA INSTITUTE OF TECHNOLOGY) 20 April 2006 (2006-04-20) paragraph [0013] - paragraph [0015] paragraph [0029] - paragraph [0032] paragraph [0045] claims 1,4,5,7,14,19,25 -----	1,2,7, 10-13,20 4-6,8,9, 14-19, 21-23
X A	US 2006/280982 A1 (HONDA MOTOR CO., LTD.) 14 December 2006 (2006-12-14) paragraph [0015] - paragraph [0020] paragraph [0062] - paragraph [0063] claims 1-4 -----	1,2,7, 9-13,20, 21 3-6,8, 14-19, 22,23
X A	JP 4 136040 A (TERUMO CORP.) 11 May 1992 (1992-05-11) abstract -----	10-13 1-9, 14-23
X A	WO 2004/040685 A2 (DAIMLERCHRYSLER AG) 13 May 2004 (2004-05-13) page 2, line 28 - page 3, line 18 page 4, line 12 - page 5, line 6 page 5, lines 21-32 example 3 claims 1, 3, 4, 6, 13, 16 -----	10,11, 14,17 1-9,12, 13,15, 16,18-23
X A	US 2006/199062 A1 (ASAHI KASEI CHEMICALS CORP.) 7 September 2006 (2006-09-07) paragraph [0014] - paragraph [0016] paragraph [0023] - paragraph [0024] paragraph [0027] paragraph [0030] - paragraph [0034] paragraph [0112] - paragraph [0113] claims 1, 9, 10, 13, 16, 18-20, 22-24 -----	1,2,4,7, 9-13,15, 17,20,23 3,5,6,8, 14,16, 18,19, 21,22
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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/025465 A1 (DAIMLERCHRYSLER AG) 6 March 2008 (2008-03-06)	1,2,4,7, 10-13, 20,22,23
A	page 5, line 30 - page 6, line 25 page 8, lines 15-20 claims 1,2,5,6,14,17	5,6,8,9, 21
X	----- R. WYCISK ET AL.: "Direct methanol fuel cell membranes from Nafion-polybenzimidazole blends", JOURNAL OF POWER SOURCES, vol. 163, no. 1, 7 December 2006 (2006-12-07), pages 9-17, XP025084657, ISSN: 0378-7753, DOI: DOI:10.1016/J.JPOWSOUR.2005.11.056 [retrieved on 2006-12-07]	1,2,4,7, 9-11,20, 22,23
A	the whole document	3,5,6,8, 12-19,21
X	----- WO 2005/072413 A2 (TOYOTA TECHNICAL CENTER USA, INC.; GEORGIA TECH RESEARCH CORP.) 11 August 2005 (2005-08-11)	10,11
A	page 2, lines 15-21 page 3, line 25 - page 4, line 14 page 8, line 21 - page 9, line 8 claims 1, 6, 20, 21, 24, 25, 27, 28, 30, 31, 37, 38	1-9, 12-23

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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.:

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: 3(completely); 1, 2, 7-13, 20, 21(partially)

A proton exchange membrane (PEM) for a membrane electrode assembly (MEA) comprising (i) a perfluorosulfonic acid or a hydrocarbon ionomer and (ii) an additive comprising at least two nitrogen atoms and capable of complexing a metal ion, said additive being a small molecule, an MEA comprising such a PEM, a process of forming such an MEA and a method of protecting the PEM of a MEA from hydroxyl radical attack using said process;

2. claims: 4-6, 22, 23(completely); 1, 2, 7-13, 20, 21(partially)

A proton exchange membrane (PEM) for a membrane electrode assembly (MEA) comprising (i) a perfluorosulfonic acid or a hydrocarbon ionomer and (ii) an additive comprising at least two nitrogen atoms and capable of complexing a metal ion, said additive being a polymer, an MEA comprising such a PEM, a process of forming such an MEA and a method of protecting the PEM of a MEA from hydroxyl radical attack using said process;

3. claims: 14-19

A reinforced proton exchange membrane (PEM) comprising (i) a perfluorosulfonic acid or a hydrocarbon ionomer and (ii) a porous polymer matrix, wherein at least one of the perfluorosulfonic acid or hydrocarbon ionomer and the porous polymer matrix comprises an additive comprising at least two nitrogen atoms.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2010/006835

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