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- 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:

21 December 2017 (21.12.2017)

(54) Title: RECHARGEABLE SODIUM CELLS FOR HIGH ENERGY DENSITY BATTERY USE

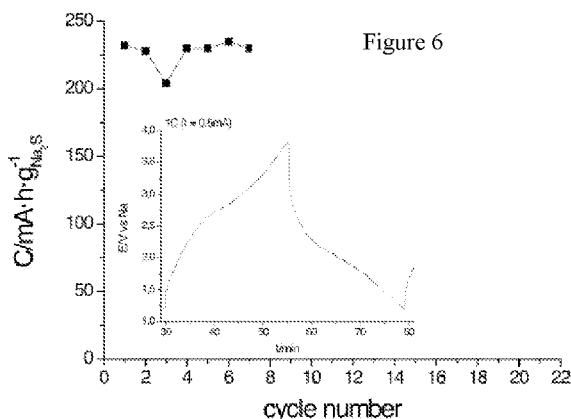


Figure 6

(57) Abstract: An electrochemical cell for an energy- dense rechargeable battery is provided. The cell includes a solid metallic sodium anode, which is deposited over a suitable current collector during the cell charging process. Several variations of compatible electrolytes are disclosed, along with novel cathode materials for building the complete high-energy battery cell.



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2017/050139

**A. CLASSIFICATION OF SUBJECT MATTER**

See extra sheet

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: H01M, H01G, B60L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base, and, where practicable, search terms used)

EPODOC, EPO-Internal full-text databases, WPIAP, XP3GPP, XPAIP, XPESP, XPETSI, XPI3E, XPIEE, XPIETF, XPIOP, XPIPCOM, XPJPEG, XPMISC, XPOAC, XPRD, XPTK, INSPEC

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008147751 A1 (TIAX LLC [US]) 04 December 2008 (04.12.2008)  page 1, lines 15-22; page 2, lines 11-16, 18-26 and 28-31; page 4, lines 16-18; page 5, lines 8-18; page 6, lines 17-21; page 7, lines 1-4 and 25-31; page 9, lines 20-27; claims 1-3, 10, 13-15; Fig. 1	1, 2, 5-6, 8, 13 (in part), 14, 15, 17-19, 21, 22 (in part), 23 (in part)
Y		7, 20
X	US 2011008680 A1 (MULDOON JOHN [US] et al.) 13 January 2011 (13.01.2011)  paragraphs [0009], [0023]-[0024]; claims 5, 11-12, 19, 23-26	1-4, 8, 13 (in part), 14-17, 21, 22 (in part)
Y		7, 20

 Further documents are listed in the continuation of Box C.
  See patent family annex.

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2017/050139

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6432587 B1 (LEE JIN-UK [KR] et al.) 13 August 2002 (13.08.2002)  abstract; column 2, lines 57-60; column 2, line 66 - column 3, line 4; claims 1, 5	1, 2, 8, 13 (in part), 14, 15, 17, 21, 22 (in part)
Y		7, 20
X	WO 2006078866 A2 (UNIV ARIZONA STATE [US]) 27 July 2006 (27.07.2006)  abstract; paragraphs [0010], [0017], [0018], [0034], [0039]; claims 9, 10, 15, 16-20, 24, 27	1, 3-6, 8, 13 (in part), 14, 16-19, 22 (in part), 23 (in part)
Y		7, 20
Y	WO 2015072577 A1 (SUMITOMO CHEMICAL CO [JP]) 21 May 2015 (21.05.2015) & a machine translation into English (Clarivate Ananlytics) [online] EPOQUENET TXPWOTEA/2017 Clarivative Analytics, claims 1-3	7, 20

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2017/050139

**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:

**Invention I :** Claims 1-9, 13 (in part), 14-21, 22 (in part), and 23 (in part) relate to electrochemical cells, methods of manufacturing of the electrochemical cells, and also to a rechargeable battery, and an electric vehicle or device. According to claim 9, the cathode material comprises partially oxidized Na<sub>2</sub>S.

**Invention II:** Claim 10 relates to an electrochemical cell, wherein the active cathode materials comprises Na<sub>2</sub>MgO<sub>2</sub> ternary oxide material. Also claims 13 (in part), 22 (in part), and 23 (in part) refer to claims 10.

**Inventions III:** Claim 11 relates to an electrochemical cell, wherein the active cathode materials comprises NaBr or NaCl : NBr mixture. Also claims 13 (in part), 22 (in part), and 23 (in part) refer to claims 11.

**Invention IV :** Claim 12 relates to an electrochemical cell, wherein the active cathode materials comprise Triazine-Quinone co-polymer. Also claims 13 (in part), 22 (in part), and 23 (in part) refer to claim 12.

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.:  
1-9, 13 (in part), 14-21, 22 (in part), and 23 (in part)

**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/FI2017/050139

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
WO 2008147751 A1	04/12/2008	CN 101779316 A	14/07/2010
		JP 2010528431 A	19/08/2010
		KR 20100038309 A	14/04/2010
		US 2010283429 A1	11/11/2010
		US 8313866 B2	20/11/2012
.....			
US 2011008680 A1	13/01/2011	US 8383276 B2	26/02/2013
		CN 102598389 A	18/07/2012
		CN 102598389 B	01/04/2015
		JP 2012531714 A	10/12/2012
		JP 5480376 B2	23/04/2014
		US 8159309 B1	17/04/2012
WO 2010151639 A2	29/12/2010		
.....			
US 6432587 B1	13/08/2002	JP 2001068152 A	16/03/2001
		KR 20010016770 A	05/03/2001
		KR 100330151 B1	28/03/2002
.....			
WO 2006078866 A2	27/07/2006	CN 101507023 A	12/08/2009
		EP 1842250 A2	10/10/2007
		EP 1842250 B1	04/09/2013
		JP 2008532209 A	14/08/2008
		JP 5318420 B2	16/10/2013
		KR 20080003774 A	08/01/2008
		KR 101101001 B1	29/12/2011
		US 2007298326 A1	27/12/2007
US 7833666 B2	16/11/2010		
US 2011020712 A1	27/01/2011		
.....			
WO 2015072577 A1	21/05/2015	WO 2015072577	16/03/2017
.....			

## CLASSIFICATION OF SUBJECT MATTER

IPC

**H01M 10/056** (2010.01)**H01M 4/13** (2010.01)**H01G 11/54** (2013.01)**H01M 10/054** (2010.01)**H01M 4/04** (2006.01)**B60L 11/18** (2006.01)