

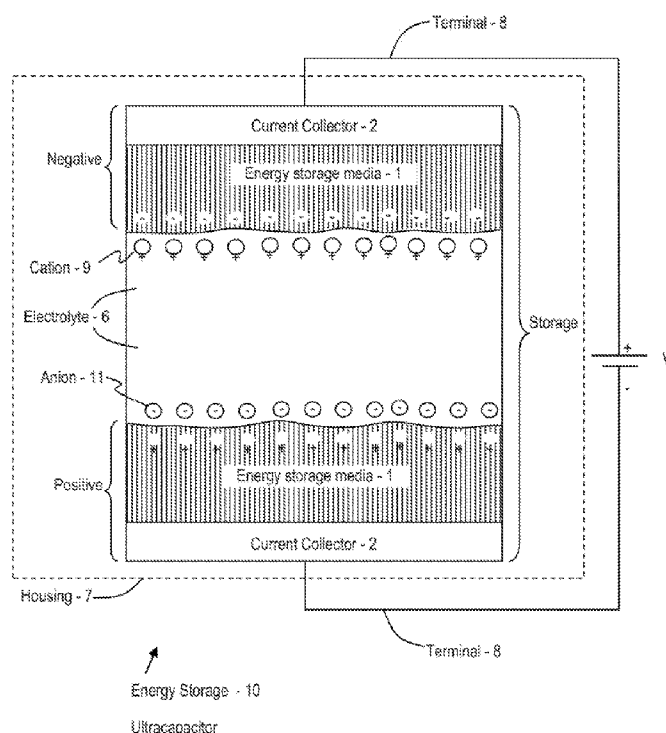


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[Continued on next page]

(54) Title: ADVANCED ELECTROLYTES FOR HIGH TEMPERATURE ENERGY STORAGE DEVICE

Fig. 1B



(57) Abstract: An ultracapacitor that includes an energy storage cell immersed in an electrolyte and disposed within an hermetically sealed housing, the cell electrically coupled to a positive contact and a negative contact, wherein the ultracapacitor has a gel or polymer based electrolyte and is configured to output electrical energy at temperatures between about -40 °C and about 250 °C. Methods of fabrication and use are provided.



PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/59971

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - H01G 11/64, H01G 11/58, H01M 10/0567 (2015.01) CPC - Y02E 60/13, H01M 2300/0022, H01M 10/0569, H01G 11/64, H01M 10/0567, H01G 11/62 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) CPC - Y02E 60/13, H01M 2300/0022, H01M 10/0569, H01G 11/64, H01M 10/0567, H01G 11/62 IPC(8) - H01G 11/64, H01G 11/58, H01M 10/0567 (2015.01) Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched CPC - Y02E60/13, H01M2300/0022, H01M10/0569, H01G11/64, H01M10/0567, H01G11/62, H01G11/00, H01G11/58 IPC(8) - H01G 11/64, H01G 11/58, H01M 10/0567 (2015.01); USPC - 361/504, 252/62.2 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Patbase; Google, Google Patent Search terms used: ionic liquid electrolyte ultracapacitor supercapacitor stability degradation additive temperature double layer														
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>WO 2012/151618 A1 (BILYK et al.) 15 November 2012 (15.11.2012), pg 1, ln 4-6; pg 9, 9-11; pg 10, ln 3-17)</td> <td>1-3</td> </tr> <tr> <td>A</td> <td>US 2011/0057151 A1 (CHEN et al.) 10 March 2011 (10.03.2011), entire document</td> <td>1-3</td> </tr> <tr> <td>A</td> <td>US 2007/0026295 A1 (ANGELL et al.) 01 February 2007 (01.02.2007), entire document</td> <td>1-3</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	WO 2012/151618 A1 (BILYK et al.) 15 November 2012 (15.11.2012), pg 1, ln 4-6; pg 9, 9-11; pg 10, ln 3-17)	1-3	A	US 2011/0057151 A1 (CHEN et al.) 10 March 2011 (10.03.2011), entire document	1-3	A	US 2007/0026295 A1 (ANGELL et al.) 01 February 2007 (01.02.2007), entire document	1-3
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☐ 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 07 July 2015 (07.07.2015)		Date of mailing of the international search report 28 JUL 2015												
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300		Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774												

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/59971

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.: 4-176, 178, 179, 183-186, 190, 194-205
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:

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 must be paid.

Group I: Claim 1-3 drawn to an electrolyte for use in an ultracapacitor.

Group II: Claims 177, 180-182, 187-189, 191-193, drawn a method for using a high temperature rechargeable energy storage device (HTRES).

-- 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.:
1-3

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

International application No.

PCT/US 14/59971

Continuation of Box No. III -- Observations where unity of invention is lacking

The inventions listed as Groups I through II 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:

Special Technical Features

Group I includes the special technical feature of an ionic liquid; and at least one additive, not included in the other groups.

Group II includes the special technical feature of maintaining a voltage across an ultracapacitor, such that the ultracapacitor will exhibit a peak power density and cycling the HTRES D by alternatively charging and discharging the HTRES D at least twice, not included in the other groups.

Common Technical Features:

The only technical feature shared by Groups I and II that would otherwise unify the groups is an ultracapacitor with an operating temperature range that comprises 0 degrees Celsius to 150 degrees Celsius. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is disclosed by WO 2012/151618 A1 to Aitchison et al. (hereinafter Aitchison).

Aitchison discloses an ultracapacitor with an operating temperature range that comprises 0 degrees Celsius to 150 degrees Celsius (pg 9, ln 31-pg 10, ln 6, supercapacitor).

As the technical feature was known in the art at the time of the invention, this cannot be considered a special technical feature that would otherwise unify the groups.

Therefore, Groups I-II lack unity under PCT Rule 13.

Note:

Claims 4-176, 178, 179, 183-186, 190, 194-205 have been held unsearchable because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).