



(51) International Patent Classification:

H01M 10/054 (2010.01) H01M 4/58 (2010.01)

H01M 10/0569 (2010.01)

(21) International Application Number:

PCT/US2024/038532

(22) International Filing Date:

18 July 2024 (18.07.2024)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

63/514,181

18 July 2023 (18.07.2023)

US

(71) Applicant: MASSACHUSETTS INSTITUTE OF TECHNOLOGY [US/US]; 77 Massachusetts Avenue, Cambridge, Massachusetts 02139 (US).

(72) Inventor; and

(71) Applicant: SHAO-HORN, Yang [US/US]; c/o MIT Technology Licensing Office, Room NE18-501, 255 Main Street, Cambridge, Massachusetts 02142 (US).

(72) Inventors: JOHNSON, Jeremiah A.; c/o MIT Technology Licensing Office, Room NE18-501, 255 Main Street, Cambridge, Massachusetts 02142 (US). WANG, Daniel; c/o MIT Technology Licensing Office, Room NE18-501, 255 Main Street, Cambridge, Massachusetts 02142 (US). LI, Ju; c/o MIT Technology Licensing Office, Room NE18-501, 255 Main Street, Cambridge, Massachusetts 02142 (US). CHEN, Weiyin; c/o MIT Technology Licensing Office, Room NE18-501, 255 Main Street, Cambridge, Massachusetts 02142 (US). RIVERA, Christian Orlando Plaza; c/o MIT Technology Licensing Office, Room NE18-501, 255 Main Street, Cambridge, Massachusetts 02142 (US). PARK, Jin-Sung; c/o MIT Technology Licensing Office, Room NE18-501, 255 Main Street, Cambridge, Massachusetts 02142 (US).

(74) Agent: GORDON, Dana M. et al.; Patent Group, Foley Hoag LLP, 155 Seaport Boulevard, Boston, Massachusetts 02210-2600 (US).

(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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,

TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every

kind of regional protection available): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

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

(88) Date of publication of the international search report:

01 May 2025 (01.05.2025)

(54) Title: FLUORINATED SULFONAMIDE-BASED ELECTROLYTES FOR NON-LITHIUM BATTERIES THEREOF

(57) Abstract: Disclosed are compositions, electrolytes, electrochemical cells, and batteries comprising a halogenated sodium salt; a halogenated sulfonate; and a co-solvent.



WO 2025/019663 A3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 24/38532

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.: 12-33, 38-41
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 supplemental page)

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.: 1-4, 6/(3-4) and 8

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 24/38532

A. CLASSIFICATION OF SUBJECT MATTER
 IPC - INV. H01M 10/054, H01M 10/0569 (2024.01)
 ADD. H01M 4/58 (2024.01)

CPC - INV. H01M 10/054, H01M 10/0569

ADD. H01M 4/5815, Y02E 60/10

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)
 See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 116169363 A (XIAN JIAOTONG UNIVERSITY) 26 May 2023 (26.05.2023); original - para [0057]; machine translation - para [n0006], [n0008], [n0015]	1-4, 6/(3-4), 8
Y	WO 2017/105578 A2 (UNIVERSITY OF MARYLAND, COLLEGE PARK) 22 June 2017 (22.06.2017); para [0002], [0014], [0101]	1-4, 6/(3-4), 8
A	WO 2023/069740 A1 (THE BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY) 27 April 2023 (27.04.2023); entire document	1-4, 6/(3-4), 8
A	US 2023/0100910 A1 (UCHICAGO ARGONNE, LLC) 30 March 2023 (30.03.2023); entire document	1-4, 6/(3-4), 8
A	US 2005/0074668 A1 (Michot et al.) 07 April 2005 (07.04.2005); entire document	1-4, 6/(3-4), 8

☐ 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
 "D" document cited by the applicant in the international application
 "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

29 October 2024 (29.10.2024)

Date of mailing of the international search report

DEC 17 2024

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

Kari Rodriguez

Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 24/38532

--continued from Box No. III--

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 searched, the appropriate additional search fees must be paid.

Group I+: Claims 1-11, directed to composition of claim 1. The composition of claim 1 will be searched to the extent that it encompasses the first species of claim 1, represented by a composition comprising a halogenated sodium salt, which is the first salt of claim 3, formula I wherein R1 and R2 are fluoro; a halogenated sulfonate, which is the first sulfonate of claim 13, formula II, wherein R3 and R4 are alkyl, which is the first alkyl of claim 14, methyl, and R5 is fluoroalkyl, which is the first fluoroalkyl listed, instant figure 23B: CF3; and a co-solvent, which is the first co-solvent of claim 18, THF (wherein optional groups are omitted). It is believed that claims 1-4, 6/(3-4) and 8 read on this first named invention, and thus these claims will be searched without fee. This first named invention has been selected based on the guidance set forth in section 10.54 of the PCT International Search and Preliminary Examination Guidelines. Applicant is invited to elect additional compounds of claim 1, wherein each additional compound elected will require one additional invention fee. Applicants must specify the claims that encompass any additionally elected compound. Applicants must further indicate, if applicable, the claims which encompass the first named invention, if different than what was indicated above for this group. Failure to clearly identify how any paid additional invention fees are to be applied to the '+' group(s) will result in only the first claimed invention to be searched. Additionally, an exemplary election wherein different actual variables are selected is suggested. An exemplary election would be a composition comprising a halogenated sodium salt, which is the first salt of claim 3, formula I wherein R1 and R2 are fluoroalkyl; a halogenated sulfonate, which is the first sulfonate of claim 13, formula II, wherein R3 and R4 are alkyl, which is the first alkyl of claim 14, methyl, and R5 is fluoroalkyl, which is the first fluoroalkyl listed, instant figure 23B: CF3; and a co-solvent, which is the first co-solvent of claim 18, THF (wherein optional groups are omitted) (i.e., claims 1-3, 5, 7/(3, 5) and 10).

Group II: Claims 34-37, directed to a non-lithium battery, comprising R1—S(=O)2—NR2R3.

The group of inventions listed above 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 technical feature of a unique composition of claim 1, which is not required by any other invention of Group I+ or II.

Group II includes the technical feature of a non-lithium battery, comprising R1—S(=O)2—NR2R3, which is not required by any other invention of Group I+.

Common technical features:

The inventions of Groups I+ share the technical feature of a composition of claim 1.

The inventions of Groups I+ and II share the technical feature of a composition comprising R1—S(=O)2—NR2R3.

These shared technical features, however, do not provide a contribution over the prior art, as being anticipated by CN 116169363 A to XIAN JIAOTONG UNIVERSITY (hereinafter Xian). Xian discloses a composition comprising a halogenated sodium salt (original – para [0057]: Table 1: example 19 - NaTFSI); a halogenated sulfonate (original – para [0057]: Table 1: example 19: CF3SO2N(CH2CH3)(CH3)); and a co-solvent (original – para [0057]: Table 1: example 19: TFP (2,2,2-trifluoroethyl phosphate) (machine translation – para [n0039])).

Xian further discloses a composition comprising R1—S(=O)2—NR2R3 wherein R1 is trifluoromethane and R2 and R3 are alkyl (Table 1: example 19: CF3SO2N(CH2CH3)(CH3)).

As said compound was known in the art, these cannot be considered special technical features that would otherwise unify the inventions of Groups I+ or II. The inventions of Group I+ and II thus lack unity under PCT Rule 13.

Note: Claims 12-33, 38-41 have been found to be unsearchable because they are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Claim 1 lacks clarity regarding "a halogenated sulfonate" as dependent compounds include sulfonamides (see instant claim 13); for the purpose of this ISR, claim 1 is assumed to a composition comprising a halogenated sodium salt; a halogenated sulfonate or sulfonamide; and a co-solvent.