



(51) International Patent Classification:

H01M 10/54 (2006.01) *C25B 9/19* (2021.01)
C25B 1/16 (2006.01) *C25B 9/15* (2021.01)
C22B 3/44 (2006.01)

(21) International Application Number:

PCT/SG2024/050719

(22) International Filing Date:

06 November 2024 (06.11.2024)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1022303185V 09 November 2023 (09.11.2023) SG

(71) Applicant: NATIONAL UNIVERSITY OF SINGAPORE [SG/SG]; 21 Lower Kent Ridge Road, Singapore 119077 (SG).

(72) Inventors: **WANG, Qing**; c/o National University of Singapore, College of Design and Engineering, Department of Materials Science and Engineering, 21 Lower Kent Ridge Road, Singapore 119077 (SG). **HUANG, Songpeng**; c/o National University of Singapore, College of Design and Engineering, Department of Materials Science and Engineering, 21 Lower Kent Ridge Road, Singapore 119077 (SG). **WANG, Xun**; c/o National University of Singapore, College of Design and Engineering, Department of Materials Science and Engineering, 21 Lower Kent Ridge Road, Singapore 119077 (SG). **ZHI, Yongfeng**; c/o National University of Singapore, College of Design and Engineering, Department of Materials Science and Engineering, 21 Lower Kent Ridge Road, Singapore 119077 (SG). **GAO,**

(54) Title: METHODS OF RECYCLING ALKALI METAL ION BATTERIES

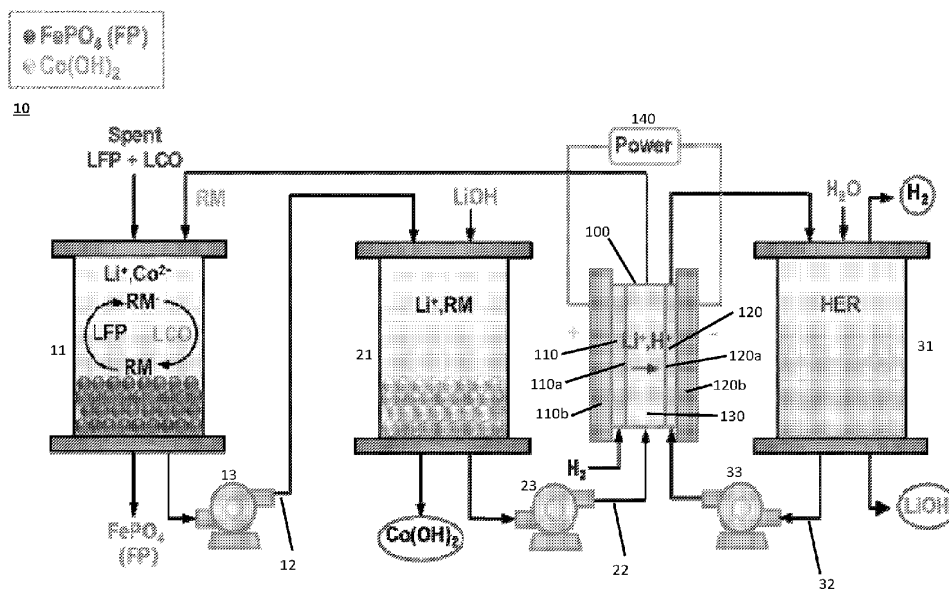


FIG. 1

(57) Abstract: The present invention provides a method of recovering one or more metals from at least two active materials obtained from an alkali metal ion battery, the method comprising (a) providing a first active material and a second active material, each of the active materials comprising alkali metal ions, the first active material having a reduction potential greater than the reduction potential of the second active material; (b) adding the first and second active materials to a redox mediator solution that comprises a solvent and a redox mediator to form a redox mediator solution comprising alkali metal ions in a first tank, wherein the redox mediator has a reduction potential that is less than the reduction potential of the first active material and greater than the reduction potential of the second active material, such that the redox mediator reduces the first active material and oxidises the second active material, thereby releasing the alkali metal ions from the first and second active materials. The redox mediator solution from step (b) of the method is

[Continued on next page]

Mengqi; c/o National University of Singapore, College of Design and Engineering, Department of Materials Science and Engineering, 21 Lower Kent Ridge Road, Singapore 119077 (SG). **SONG, Yuxi**; c/o National University of Singapore, College of Design and Engineering, Department of Materials Science and Engineering, 21 Lower Kent Ridge Road, Singapore 119077 (SG).

(74) **Agent: KINNAIRD, James Welsh**; Marks & Clerk Singapore LLP, Tanjong Pagar Post Office, P.O. Box 636, Singapore 910816 (SG).

(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).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

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

then processed to allow capture of the alkali metal ions as an alkali metal hydroxide according to steps (c) to (e) as disclosed herein.