

CHUNG HYUN PATENT & LAW FIRM

보낸 사람: Herrman, Audrey M. <AMHerrman@duanemorris.com>
보낸 날짜: 2024년 11월 16일 토요일 오전 4:47
받는 사람: CHUNG HYUN PATENT & LAW FIRM
참조: 양진 변리사님; 김형주 부장님; 김병관 차장; Lefkowitz, Gregory M.; Boca Raton-Patent
제목: APPLICATION FILED & REQUEST FOR SIGNED FORMAL DOCUMENTS - U.S. Patent
Application No. 18/949,038; Your Ref: HOP574-US; Our Ref: G1035-29701
첨부 파일: G1035-29701 EAR & Application filed 11.15.2024.PDF; G1035-29701 Assignment from
Inventor.DOCX; G1035-29701 PANG Declaration.PDF; G1035-29701 OH
Declaration.PDF; G1035-29701 HAN Declaration.PDF; G1035-29701 LEE
Declaration.PDF

RE: U.S. Patent Application No. 18/949,038

**Title: SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID
ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING
THE SAME, AND METHODS OF MAKING THE SAME**

Your Ref: HOP574-US; Our Ref: G1035-29701

Dear Mr. Yang:

Please be advised that the U.S. application was filed today, November 15, 2024, with the U.S. Patent and Trademark Office, and accorded U.S. serial number 18/949,038. Attached are the filed documents and PTO Acknowledgement Receipt confirming the same.

Request for Signed Formal Documents

Attached are inventor Declarations and an Assignment. Please have the inventors sign these documents, then return them to us via email as soon as possible – we do not need the originals. We already have a signed Power of Attorney for UIF (University Industry Foundation), Yonsei University and will use it in this application.

Information Disclosure Statement (IDS) Requirement

Please note patent applicants have a duty, which is ongoing and continues throughout the pendency of an application, to disclose to the USPTO all prior art known to the applicant which is material to patentability of the claims. Information material to patentability is defined, in part, as information that establishes by itself or in combination with other information, a *prima facie* case of unpatentability of a claim, refutes or is inconsistent with a position the applicant takes in opposing an argument of unpatentability made by the Patent Office or takes in asserting an argument of patentability. The USPTO imposes this obligation on the applicant, any employer for whom the applicant works, and the applicant's attorney. The disclosure must be made in writing to the USPTO in a form that is referred to as an information disclosure statement (IDS). As a general practice, it is preferable to err on the side of submitting information and letting the Examiner determine whether the reference is material to patentability. Accordingly, should you be or become aware of any information relevant to the determination of patentability for this invention, we ask that you submit that information to us, and the date you became aware of it, so that we may submit such information to the USPTO in an IDS.

Our reference number for this matter is G1035-29701.

We will keep you informed of further developments as they occur. In the meantime, if you have any questions, please do not hesitate to contact us.

Regards,
Audrey

Audrey M. Herrman
IP Paralegal

Duane Morris LLP
Boca Center Tower II
5100 Town Center Circle
Suite 400
Boca Raton, Florida 33486-1008
P: 561-962-2120

amherrman@duanemorris.com
www.duanemorris.com

For more information about Duane Morris, please visit <http://www.DuaneMorris.com>

Confidentiality Notice: This electronic mail transmission is privileged and confidential and is intended only for the review of the party to whom it is addressed. If you have received this transmission in error, please immediately return it to the sender. Unintended transmission shall not constitute waiver of the attorney-client or any other privilege.



UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/949,038

RECEIPT DATE / TIME
11/15/2024 02:09:51 PM Z ET

ATTORNEY DOCKET #
G1035-29701

Title of Invention

SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING THE SAME, AND METHODS OF MAKING THE SAME

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 3367

FILED BY Audrey Herrman

PATENT CENTER # 67977861

FILING DATE -

CUSTOMER # 11753

FIRST NAMED
INVENTOR Sang-Young LEE

CORRESPONDENCE
ADDRESS -

AUTHORIZED BY Gregory Lefkowitz

Documents

TOTAL DOCUMENTS: 10

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
G1035-29701_AppTL.pdf	1	Transmittal of New Application	234 KB
G1035-29701_ADS.pdf	8	Application Data Sheet	124 KB
Warning: This is not a USPTO supplied ADS fillable form. Data in the form cannot be automatically loaded to other USPTO systems.			
G1035-29701_Specification-APP.TEXT.docx	36	Application body structured text document	52 KB
Warning: Document has [Balance SBCS characters and DBCS characters] option enabled and may result in reduction of pages, however, no data or text has been modified.			
G1035-29701_Drawings.pdf	4	Drawings-only black and white line drawings	1019 KB

G1035-29701_IDS.pdf	3	Information Disclosure Statement (IDS) Form (SB08)	82 KB
Warning: This is not a USPTO supplied IDS fillable form. Data in the form cannot be automatically loaded to other USPTO systems.			
FOR_KR102567762.pdf	31	Foreign Reference	851 KB
FOR_WO2023002015.pdf	22	Foreign Reference	3304 KB
NPL_KIM_Theeffect.pdf	8	Non Patent Literature	508 KB
NPL_LIU_Designing.pdf	33	Non Patent Literature	7954 KB
G1035-29701_Specification.pdf	36	Auxiliary PDF of Application	223 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
G1035-29701_AppTL.pdf	F11C52655A9D996E9408FD57F8584196D1E62324DF4A46166237131CFFFB150B90DA997ADD9DF8C7E13F91089D634934E5677B6C02DE843FA81103F0A51EF6DA
G1035-29701_ADS.pdf	9BA184140F44F761AA474B91286CFD75185A85CE4C58B98B15AD25CDE9A799AD81824E3DAFB6085255B9D794135095665BC67C8A72DB54B1667FF57F770B8A08
G1035-29701_Specification-APP.TEXT.docx	8CAB2DEC6525D83DE91100469A98AA28408D45AAD5BD4863055019F1582A53CC614E87625C960592DC1EFA391EEDE3670AA8C0F3875572DA35223DE228046905
G1035-29701_Drawings.pdf	E1ABBA7E2062FBD6BF925845E00E5DBC3C6F5537753B07445EE5F1102E2F6A1B1FA3ED0B12584EA4E4E4ADAA0D3D5D77A7A4D8AA76321B4B0DC0B4D14349AF6C
G1035-29701_IDS.pdf	3439A1D3BCE731A68D3F2E55CDBEFAEE5608004000EA3E27258DC53AFF313C6C3C7DE2D40CBFC6C65A7E3B330D700C54EC35ABC86A98F7941CA8757240F3F3CD
FOR_KR102567762.pdf	57F382F19F34FDFEF2631D503E3A0B99D925925C0A701050B2A5386515180D196C84895E1564ED5A7EC8F542D67EE08FE052456960DF8E1ADE81192E3185D071
FOR_WO2023002015.pdf	BEAAE9857DC63883BA17D2C6D99B72AFEB00BD0AF430798349D6ED3FFB45ACF3764AF058BD8418DAB541B0569059D630BA24468722D3E9887F673912C808197F
NPL_KIM_Theeffect.pdf	2294C1EEE883FC573E499F3460591C6DF176084387F539515D0711383A4DB97D63318BBA18130F16FCE3D946626E691A717F4CB1DDCD289B452CAD93C9D0C8AF

NPL_LIU_Designing.pdf

5C6DCD876804FAA25FBB318AD14302197FA79108D451493F3
 7D1DE1DCA25EBD9043F1AD8BDE6BC150D7EB53308291B8D
 3483360B640CEA9F54EA2A75E6EA17F1

G1035-29701_Specification.pdf

126889E0C25C0F06CA73C79EAE55DCCE013172481133CB505
 FA02671121C93693BC0CA36EFB4993539176F8298CC99B3FC
 4391887D6A84C625D22D2020949FE4

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES
PATENT AND TRADEMARK OFFICEP.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #
18/949,038RECEIPT DATE / TIME
11/15/2024 02:09:51 PM Z ETATTORNEY DOCKET #
G1035-29701

Title of Invention

SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING THE SAME, AND METHODS OF MAKING THE SAME

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 3367

FILED BY Audrey Herrman

PATENT CENTER # 67977861

AUTHORIZED BY Gregory Lefkowitz

CUSTOMER # 11753

FILING DATE -

CORRESPONDENCE
ADDRESS -FIRST NAMED
INVENTOR Sang-Young LEE

Payment Information

PAYMENT METHOD
DA / 041679PAYMENT TRANSACTION ID
E2024AEE10317238PAYMENT AUTHORIZED BY
Audrey Herrman

FEE CODE	DESCRIPTION	ITEM PRICE(\$)	QUANTITY	ITEM TOTAL(\$)
2051	SURCHARGE- LATE FILING FEE, SEARCH FEE, EXAMINATION FEE, INVENTOR'S OATH OR DECLARATION, OR APPLICATION FILED WITHOUT AT LEAST ONE CLAIM OR BY REFERENCE	64.00	1	64.00
2111	UTILITY PATENT APPL. SEARCH FEE	280.00	1	280.00
4011	BASIC FILING FEE- UTILITY	64.00	1	64.00
2311	EXAMINATION OF ORIGINAL PATENT APPLICATION	320.00	1	320.00
2201	EACH INDEPENDENT CLAIM IN EXCESS OF THREE	192.00	1	192.00

**TOTAL
AMOUNT:****\$920.00**

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Under the Paperwork Reduction Act of 1995 no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UTILITY PATENT APPLICATION TRANSMITTAL (Only for new nonprovisional applications under 37 CFR 1.53(b))	Attorney Docket No.	G1035-29701
	First Named Inventor	Sang-Young LEE
	Title	SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES
	Priority Mail Express® Label No.	

APPLICATION ELEMENTS <i>See MPEP chapter 600 concerning utility patent application contents.</i>	ADDRESS TO: Commissioner for Patents P.O. Box 1450 Alexandria, VA 22313-1450
<p>1. <input type="checkbox"/> Fee Transmittal Form (PTO/SB/17 or equivalent)</p> <p>2. <input checked="" type="checkbox"/> Applicant asserts small entity status. See 37 CFR 1.27</p> <p>3. <input type="checkbox"/> Applicant certifies micro entity status. See 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.</p> <p>4. <input checked="" type="checkbox"/> Specification [Total Pages <u>36</u>] Both the claims and abstract must start on a new page. (See MPEP § 608.01(a) for information on the preferred arrangement)</p> <p>5. <input checked="" type="checkbox"/> Drawing(s) (35 U.S.C. 113) [Total Sheets <u>4</u>]</p> <p>6. Inventor's Oath or Declaration [Total Pages _____] (including substitute statements under 37 CFR 1.64 and assignments serving as an oath or declaration under 37 CFR 1.63(e))</p> <p>a. <input type="checkbox"/> Newly executed (original or copy)</p> <p>b. <input type="checkbox"/> A copy from a prior application (37 CFR 1.63(d))</p> <p>7. <input checked="" type="checkbox"/> Application Data Sheet *See note below. See 37 CFR 1.76 (PTO/AIA/14 or equivalent)</p> <p>8. CD-ROM or CD-R in duplicate, large table, or Computer Program (Appendix)</p> <p><input type="checkbox"/> Landscape Table on CD</p> <p>9. Nucleotide and/or Amino Acid Sequence Submission (if applicable, items a. – c. are required)</p> <p>a. <input type="checkbox"/> Computer Readable Form (CRF)</p> <p>b. <input type="checkbox"/> Specification Sequence Listing on:</p> <p>i. <input type="checkbox"/> CD-ROM or CD-R (2 copies); or</p> <p>ii. <input type="checkbox"/> Paper</p> <p>c. <input type="checkbox"/> Statements verifying identity of above copies</p>	ACCOMPANYING APPLICATION PAPERS <p>10. <input type="checkbox"/> Assignment Papers (cover sheet & document(s)) Name of Assignee _____</p> <p>11. <input type="checkbox"/> 37 CFR 3.73(c) Statement <input type="checkbox"/> Power of Attorney (when there is an assignee)</p> <p>12. <input type="checkbox"/> English Translation Document (if applicable)</p> <p>13. <input checked="" type="checkbox"/> Information Disclosure Statement (PTO/SB/08 or PTO-1449) <input checked="" type="checkbox"/> Copies of citations attached</p> <p>14. <input type="checkbox"/> Preliminary Amendment</p> <p>15. <input type="checkbox"/> Return Receipt Postcard (MPEP § 503) (Should be specifically itemized)</p> <p>16. <input type="checkbox"/> Certified Copy of Priority Document(s) (if foreign priority is claimed)</p> <p>17. <input type="checkbox"/> Nonpublication Request Under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent.</p> <p>18. <input type="checkbox"/> Other: _____ _____ _____ _____</p>

***Note:** (1) Benefit claims under 37 CFR 1.78 and foreign priority claims under 1.55 **must** be included in an Application Data Sheet (ADS).
(2) For applications filed under 35 U.S.C. 111, the application must contain an ADS specifying the applicant if the applicant is an assignee, person to whom the inventor is under an obligation to assign, or person who otherwise shows sufficient proprietary interest in the matter. See 37 CFR 1.46(b).

19. CORRESPONDENCE ADDRESS				
<input checked="" type="checkbox"/> The address associated with Customer Number: <u>11753</u> OR <input type="checkbox"/> Correspondence address below				
Name				
Address				
City	State	Zip Code		
Country	Telephone	Email		
Signature	/Gregory M. Lefkowitz/		Date	November 15, 2024
Name (Print/Type)	/Gregory M. Lefkowitz/		Registration No. (Attorney/Agent)	56,216

A Federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with an information collection subject to the requirements of the Paperwork Reduction Act of 1995, unless the information collection has a currently valid OMB Control Number. The OMB Control Number for this information collection is 0651-0032. Public burden for this form is estimated to average 12 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the information collection. Send comments regarding this burden estimate or any other aspect of this information collection, including suggestions for reducing this burden to the Chief Administrative Officer, United States Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450 or email InformationCollection@uspto.gov. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. If filing this completed form by mail, send to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	G1035-29701
		Application Number	
Title of Invention	SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING THE SAME, AND METHODS OF MAKING THE SAME		
<p>The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.</p> <p>This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.</p>			

Secrecy Order 37 CFR 5.2:

<input type="checkbox"/>	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
--------------------------	---

Inventor Information:

Inventor 1					Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Sang-Young		LEE		
Residence Information (Select One) <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
City	Seoul	Country of Residence ⁱ		KR	
Mailing Address of Inventor:					
Address 1		207ho, GS Caltex Research Hall, 50, Yonsei-ro			
Address 2		Seodaemun-gu			
City	Seoul	State/Province			
Postal Code		03722	Country ⁱ	KR	
Inventor 2					Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Kyeong-Seok		OH		
Residence Information (Select One) <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
City	Seoul	Country of Residence ⁱ		KR	
Mailing Address of Inventor:					
Address 1		207ho, GS Caltex Research Hall, 50, Yonsei-ro			
Address 2		Seodaemun-gu			
City	Seoul	State/Province			
Postal Code		03722	Country ⁱ	KR	
Inventor 3					Remove
Legal Name					

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	G1035-29701
		Application Number	
Title of Invention	SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING THE SAME, AND METHODS OF MAKING THE SAME		

Prefix	Given Name	Middle Name	Family Name	Suffix
	Dong-Yeob		HAN	
Residence Information (Select One) <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="radio"/> Active US Military Service				
City	Seoul	Country of Residence ⁱ	KR	

Mailing Address of Inventor:

Address 1	207ho, GS Caltex Research Hall, 50, Yonsei-ro			
Address 2	Seodaemun-gu			
City	Seoul	State/Province		
Postal Code	03722	Country ⁱ	KR	
Inventor 4				<button>Remove</button>
Legal Name				

Prefix	Given Name	Middle Name	Family Name	Suffix
	Jung Hyun		PANG	
Residence Information (Select One) <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="radio"/> Active US Military Service				
City	Seoul	Country of Residence ⁱ	KR	

Mailing Address of Inventor:

Address 1	207ho, GS Caltex Research Hall, 50, Yonsei-ro			
Address 2	Seodaemun-gu			
City	Seoul	State/Province		
Postal Code	03722	Country ⁱ	KR	
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button. <div style="float: right;"><button>Add</button></div>				

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).	
<input type="checkbox"/> An Address is being provided for the correspondence Information of this application.	
Customer Number	11753
Email Address	<div style="float: right;"> <div><button>Add Email</button></div> <div><button>Remove Email</button></div> </div>

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	G1035-29701
		Application Number	
Title of Invention	SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING THE SAME, AND METHODS OF MAKING THE SAME		

Application Information:

Title of the Invention	SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING THE SAME, AND METHODS OF MAKING THE SAME		
Attorney Docket Number	G1035-29701	Small Entity Status Claimed	<input checked="" type="checkbox"/>
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	4	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

<input type="checkbox"/> Request Early Publication (Fee required at time of Request 37 CFR 1.219)
<input type="checkbox"/> Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

<p>Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.</p>			
Please Select One:	<input checked="" type="radio"/> Customer Number	<input type="radio"/> US Patent Practitioner	<input type="radio"/> Limited Recognition (37 CFR 11.9)
Customer Number	11753		

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	G1035-29701
		Application Number	
Title of Invention	SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING THE SAME, AND METHODS OF MAKING THE SAME		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

			Remove
Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)
10-2023-0158946	KR	2023-11-16	5D68
			Remove
Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)
10-2023-0158951	KR	2023-11-16	2CCB

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

<input type="checkbox"/> This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	G1035-29701
		Application Number	
Title of Invention	SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING THE SAME, AND METHODS OF MAKING THE SAME		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	G1035-29701
		Application Number	
Title of Invention	SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING THE SAME, AND METHODS OF MAKING THE SAME		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.			
Applicant 1			
<p>If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.</p>			
<input type="button" value="Clear"/>			
<input checked="" type="radio"/> Assignee		<input type="radio"/> Legal Representative under 35 U.S.C. 117	
<input type="radio"/> Person to whom the inventor is obligated to assign.		<input type="radio"/> Joint Inventor	
<input type="radio"/> Person who shows sufficient proprietary interest			
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:			
Name of the Deceased or Legally Incapacitated Inventor: <input type="text"/>			
If the Applicant is an Organization check here. <input checked="" type="checkbox"/>			
Organization Name	UIF (UNIVERSITY INDUSTRY FOUNDATION), YONSEI UNIVERSITY		
Mailing Address Information For Applicant:			
Address 1	50, Yonsei-ro, Seodaemun-gu		
Address 2			
City	Seoul	State/Province	
Country	KR	Postal Code	03722
Phone Number		Fax Number	
Email Address			
Additional Applicant Data may be generated within this form by selecting the Add button.			

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	G1035-29701
		Application Number	
Title of Invention	SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING THE SAME, AND METHODS OF MAKING THE SAME		

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☒

Organization Name	UIF (UNIVERSITY INDUSTRY FOUNDATION), YONSEI UNIVERSITY
-------------------	---

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1		50, Yonsei-ro, Seodaemun-gu	
Address 2			
City		Seoul	State/Province
Country ⁱ	KR	Postal Code	03722
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Gregory M. Lefkowitz/		Date (YYYY-MM-DD)	2024-11-15
First Name	Gregory	Last Name	Lefkowitz	Registration Number
56,216				

Additional Signature may be generated within this form by selecting the Add button.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	G1035-29701
		Application Number	
Title of Invention	SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED SOLID ELECTROLYTES OR CATHODES, POLYMERIC ELECTROLYTES OR ELECTRODES USING THE SAME, AND METHODS OF MAKING THE SAME		

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

**SOLVENT-FREE COMPOSITIONS FOR MAKING POLYMER-BASED
SOLID ELECTROLYTES OR CATHODES, POLYMERIC
ELECTROLYTES OR ELECTRODES USING THE SAME, AND
METHODS OF MAKING THE SAME**

5

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 U.S.C. §119 to Korean Patent Application Nos.
10-2023-0158946 and 10-2023-0158951 filed on November 16, 2023 and November 16, 2023,
respectively in the Korean Intellectual Property Office, the disclosure of which is incorporated
10 herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Technology

The present invention relates to a solvent-free composition for the preparation of a
15 polymeric solid electrolyte or cathode, a polymeric electrolyte or electrode utilizing the
composition, and a method for preparing the same.

Technology behind the invention

Recent developments in the advanced electronics industry have enabled miniaturization
20 and lightweighting of electronic equipment, which has led to an increase in the use of portable
electronic devices. In particular, secondary cellies composed of metal-oxygen, metal-air, other
metal and gas mixtures, and all-solid-state batteries can have a theoretical specific energy that is
three to five times higher than conventional batteries due to the atomic density and high reduction
capacity caused by the low atomic number of lithium, for example, used as the metal. The need

for batteries with high energy density to power portable electronic devices has increased, and research on lithium secondary cellies is actively underway.

5 A secondary cell, such as a lithium secondary cell or a supercapacitor, includes an anode and a cathode, and an electrolyte that separates said cathode from said anode, and through which ions are conducted. Types of said electrolyte include liquid electrolyte and solid electrolyte.

Liquid electrolytes have the advantage of high ionic conductivity due to the free movement of ions within the electrolyte. However, liquid electrolyte requires injection and wetting processes, which increases the process time excessively. In addition, liquid electrolyte can cause the internal pressure of the secondary cell to increase and risk leakage, and if the separator is
10 damaged by deformation or external impact, it can cause a short circuit, which can lead to overheating or explosion.

As an alternative, all-solid-state batteries, which replace liquid electrolytes with solid electrolytes, are being developed, and these solid electrolytes are mainly polymer electrolytes based on polymers. Solid electrolytes based on polymers have the advantages of increasing the
15 safety of the battery, improving the reliability of the battery by preventing leakage of the electrolyte, and making it easier to manufacture thin batteries. However, solid electrolytes have low ionic conductivity due to the crystallinity of the polymer and restrictions on the movement of ions due to the complex molecular chains, resulting in poor output characteristics at low temperatures. In addition, solid electrolytes have poorer surface adhesion to the active material compared to liquid
20 electrolytes, resulting in increased interfacial resistance, and the solid electrolyte is distributed in a non-contact state with the electrode active material, resulting in a decrease in output characteristics and capacity characteristics compared to the amount of conductive material used. In addition, there are economic limitations due to the high cost of materials and the high

temperature and pressure processes required. In particular, in polymer-based solid electrolytes such as PEO, binders have been required to be used due to low adhesion due to weak intermolecular interactions with the electrolyte, and the energy characteristics of the cell are degraded due to the introduction of binders.

5 Therefore, there is an urgent need to develop polymer electrolytes that are stable, have excellent electrochemical properties, and can be manufactured in a simple process, and binder-free electrodes using them.

Prior art

10 Patent Literature

(Patent Reference 1) Patent Reference 1. Korean Registered Patent No. 10-2567762

Invention Description

The problem you want to solve

15 It is an object of the present invention to provide a solvent-free composition for the preparation of a polymeric solid electrolyte or electrode, the composition comprising a liquid monomer; and a lithium salt, wherein the lithium salt is included in an excess amount over the liquid monomer.

 It is also an object of the present invention to provide a polymer-based electrolyte or
20 cathode prepared by crosslinking a solvent-free composition for the preparation of said polymeric solid electrolyte or cathode.

 It is also an object of the present invention to provide a secondary cell comprising said polymer-based electrolyte or said cathode or both.

It is also an object of the present invention to provide an apparatus comprising said secondary cell, said apparatus being wherein it is selected from the group consisting of a communication equipment, an energy storage system (ESS), and a transportation vehicle.

It is also an object of the present invention to provide a method for preparing a polymeric solid electrolyte comprising (A) obtaining a solvent-free composition for preparing a polymeric solid electrolyte comprising a liquid monomer and an excess of lithium salt; and (B) crosslinking said polymeric solid electrolyte.

It is also an object of the present invention to provide a method of manufacturing a cathode, comprising: (A) obtaining a solvent-free composition for manufacturing a cathode, the composition comprising a liquid monomer, an excess of lithium salt, a cathode active material, and a coating material; and (B) coating and crosslinking said solvent-free composition for manufacturing a cathode onto a substrate.

Solution to the challenge

One aspect of the present invention provides a solvent-free composition for making a polymeric solid electrolyte comprising a liquid monomer; and a lithium salt, wherein said lithium salt is included in an excess amount over said liquid monomer.

With respect to said 100 parts by weight of liquid monomer, said lithium salt may be from 120 to 350 parts by weight.

The liquid monomer may comprise one or more functional groups selected from the group of monomers comprising carbonyl groups, amine groups, epoxy groups, phenolic groups, urethane groups, and acrylate groups.

Examples of the above lithium salts include but are not limited to at least one selected

from LiBOB, LiFOB, LiDFBP, $\text{Li}(\text{CF}_3\text{SO}_2)_2$, $\text{Li}(\text{CF}_3\text{SO}_2)_2\text{CH}$, $\text{Li}(\text{CF}_3\text{SO}_2)_3\text{C}$, $\text{LiCF}_3(\text{CF}_2)_7\text{SO}_3$, LiCF_3SO_3 , $\text{LiCF}_3\text{CF}_2\text{SO}_3$, LiTFO, LiClO_4 , LiSbF_6 , LiAsF_6 , LiPF_6 , $\text{Li}(\text{CF}_3)_2\text{PF}_4$, $\text{Li}(\text{CF}_3)_3\text{PF}_3$, $\text{Li}(\text{CF}_3)_4\text{PF}_2$, $\text{Li}(\text{CF}_3)_5\text{PF}$, $\text{Li}(\text{CF}_3)_6\text{P}$, LiCTFSI ($\text{LiN}(\text{C}_2\text{F}_4\text{S}_2\text{O}_4)$), LiBETI ($\text{LiC}_4\text{NO}_4\text{F}_{10}\text{S}_2$), LiFSI ($\text{LiNO}_4\text{F}_2\text{S}_2$) and LiTFSI ($\text{LiC}_2\text{NO}_4\text{F}_6\text{S}_2$).

5 The combination of said liquid monomer and said lithium salt (liquid monomer, lithium salt) may be at least one selected from the group consisting of (bisphenol A, LiBETI), (bisphenol F, LiFSI), (polyester polyol, LiTFSI), (Novalak, LiFSI), (polyether polyol, LiBETI), and (acrylic acid, LiTFSI).

 Another aspect of the present invention provides a polymer-based electrolyte prepared by
10 crosslinking said polymer-based electrolyte composition.

 Another aspect of the present disclosure provides an electrode comprising: a solvent-free composition for making a polymer-based solid electrolyte; and an electrode active material.

 The solvent-free composition for making said polymeric solid electrolyte may comprise from 9 to 23 wt%, based on 100 wt% of the total of said electrodes.

15 The electrode active material may comprise one or more species selected from the group consisting of LCO (LiCoO_2), NCM111 ($\text{LiNi}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3}\text{O}_2$), NCM622 ($\text{LiNi}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$), NCM811 ($\text{LiNi}_{0.8}\text{Co}_{0.1}\text{Mn}_{0.1}\text{O}_2$), LMO (LiMn_2O_4) 및 LNMO ($\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$).

 The electrode may further comprise a conductive material.

 The coating material may comprise at least one type selected from the group consisting of
20 Super P, Super C, carbon black, Ketjenblack, natural graphite, artificial graphite, carbon black, acetylene black, lamp black, furnace black, and summer black.

 The solvent-free composition for making said electrode active material, said coating material and said polymeric solid electrolyte may comprise from 70 to 90 : 1 to 7 : 9 to 23 by

weight.

Another aspect of the present invention provides a secondary cell comprising said electrodes.

Another aspect of the present invention provides an apparatus comprising said secondary cell, wherein said apparatus is selected from the group consisting of a communication device, an energy storage system (ESS), and a transportation vehicle.

Another aspect of the present invention provides a method of preparing a solvent-free polymeric solid electrolyte comprising: (A) mixing a liquid monomer and an excess of lithium salt to obtain a solvent-free composition for preparing a polymeric solid electrolyte; and (B) crosslinking said polymeric solid electrolyte composition.

With respect to said 100 parts by weight of liquid monomer, said lithium salt may be from 120 to 350 parts by weight.

The liquid monomer may comprise one or more functional groups selected from the group consisting of carbonyl groups, amine groups, epoxy groups, phenolic groups, urethane groups, and acrylate groups.

Examples of the above lithium salts include but are not limited to at least one selected from LiBOB, LiFOB, LiDFBP, Li(CF₃SO₂)₂, Li(CF₃SO₂)₂CH, Li(CF₃SO₂)₃C, LiCF₃(CF₂)₇SO₃, LiCF₃SO₃, LiCF₃CF₂SO₃, LiTFO, LiClO₄, LiSbF₆, LiAsF₆, LiPF₆, Li(CF₃)₂PF₄, Li(CF₃)₃PF₃, Li(CF₃)₄PF₂, Li(CF₃)₅PF, Li(CF₃)₆P, LiCTFSI (LiN(C₂F₄S₂O₄)), LiBETI (LiC₄NO₄F₁₀S₂), LiFSI (LiNO₄F₂S₂) and LiTFSI (LiC₂NO₄F₆S₂).

The combination of said liquid monomer and said lithium salt (liquid monomer, lithium salt) may be at least one selected from the group consisting of (bisphenol A, LiBETI), (bisphenol F, LiFSI), (polyester polyol, LiTFSI), (Novalak, LiFSI), (polyether polyol, LiBETI), and (acrylic

acid, LiTFSI).

The crosslinking may be performed by heat treatment or UV irradiation.

Said crosslinking may be carried out by heat treatment at 50 to 90°C for 0.8 to 4 hours.

The crosslinking may be performed by irradiating with UV for 0.5 to 6 minutes.

5 The solvent-free composition for making a polymeric solid electrolyte further comprises a photoinitiator, said photoinitiator being selected from 2-hydroxy-2-methylpropiophenone (HMPP), 2,4,6-trimethyl benzoyl diphenyl phosphine (TPO), and benzildimethylketal (BDK), the photoinitiator may be at least one selected from the group consisting of 2-hydroxy-2-methylpropiophenone (HMPP), 2,4, 6-trimethyl benzoyl diphenyl phosphine (TPO), and
10 benzildimethylketal (BDK).

The solvent-free composition for making said polymeric solid electrolyte may further comprise from 1.3 to 2 parts by weight of a photoinitiator, based on a total of 100 parts by weight of said liquid monomer and said lithium salt.

Another aspect of the present invention provides a method of preparing an electrode,
15 comprising (I) mixing a liquid monomer and an excess of lithium salt to obtain a solvent-free composition for preparing a polymeric solid electrolyte; (II) mixing an electrode active material and said polymeric solid electrolyte solvent-free composition to prepare an electrode slurry; and (III) crosslinking said electrode slurry to prepare an electrode.

20 Effect of Invention

The polymer electrolyte compositions according to the present invention can exhibit good dispersibility without the need for process solvents, and can solve the problems caused by the residual solvent.

Furthermore, the polymer electrolyte compositions of the present invention can exhibit high oxidative stability due to their high concentration electrolyte properties, and can exhibit wide potential window properties.

Furthermore, the polymer electrolyte of the present invention can exhibit high adhesion to the collector due to strong intermolecular interactions.

The effects of the present invention are not limited to those mentioned above. The effects of the invention are to be understood to include all effects that can be inferred from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

Short description of the drawing

FIG. 1 illustrates a method of fabrication and a schematic diagram of an electrode according to one embodiment of the present invention.

FIG. 2 is a simplified schematic illustration of an electrode fabricated in an Example of the present invention.

FIG. 3 shows the ionic conductivity and activation energy of the polymer-based electrolytes prepared in Example 1 (1/2), Comparative Example 1 (4/1), Comparative Example 2 (2/1), and Comparative Example 3 (1/1) of the present invention.

FIG. 4 shows the results of the oxidation stability and adhesion force evaluations of the polymer electrolyte and electrodes prepared in Example 1 (MIS, 1/2), Comparative Example 1 (4/1), Comparative Example 2 (2/1), Comparative Example 3 (1/1), and Comparative Example 4 (PIS) of the present invention and the electrodes using PEO, PVdF, and PAA.

FIG. 5 shows the specific capacity and coulombic efficiency as a function of the number

of cycles of the electrode prepared in Example 1 (AA-based MIS) and Comparative Example 4 (PAA-based PIS) of the present invention and the electrode utilizing PEO as a polymeric or polymer-based electrolyte (PEO-based PIS).

FIG. 6 shows the results of the electrochemical characterization of the electrodes prepared in Example 1 and Comparative Example 5 of the present invention.

[Specific details for practicing the invention].

The advantages and features of the present invention, and methods of achieving them, will become apparent upon reference to the embodiments described in detail with reference to the accompanying drawings. However, the invention is not limited to the embodiments disclosed herein, but will be embodied in many different forms, and these embodiments are provided merely to make the disclosure of the invention complete and to give a complete picture of the scope of the invention to those having ordinary skill in the art to which the invention belongs, and the invention is defined by the scope of the claims.

Further, the terms "comprising" or "having" and the like are intended to designate the presence of the features, numbers, steps, components, or combinations thereof described, and not to be construed as excluding the possibility of the presence or addition of one or more other features, numbers, steps, components, or combinations thereof. Further, where components are expressed in the singular, they include the plural unless otherwise expressly indicated.

The invention will now be described in more detail below.

As mentioned above, liquid electrolytes are prone to internal pressure increase and leakage, which can lead to short circuits if the separator is damaged by deformation or external impact, or even worse, overheating or explosion. Solid electrolytes were developed as an alternative, but solid electrolytes have low ionic conductivity, high interfacial resistance, resulting in poor output and

capacity characteristics, and are not economical in terms of manufacturing processes.

Accordingly, the present invention provides a solvent-free polymer electrolyte composition comprising a liquid monomer; and a lithium salt, wherein said lithium salt is included in an excess amount over said liquid monomer, and improves ionic conductivity and electrochemical properties without suffering from any stability problems seen in liquid electrolytes, while also reducing cost and time in terms of manufacturing process.

More specifically, one aspect of the present invention provides a solvent-free composition for making a polymeric solid electrolyte comprising a liquid monomer; and a lithium salt, wherein said lithium salt is included in an excess amount over said liquid monomer.

The polymer electrolyte composition according to the present invention is wherein it comprises a liquid monomer and a lithium salt, wherein said lithium salt is in excess of said liquid monomer and is solvent-free, so that it can exhibit excellent oxidation stability with wide potential window characteristics. If any of the above technical features of the present invention are not satisfied, the oxidation stability may be reduced, and the narrow potential window may cause decomposition during long-term operation at high voltage, making it unsuitable for use as a polymer electrolyte.

In particular, the polymer electrolyte composition of the present invention is characterized by being solvent-free, which can increase process economy by omitting the injection and wetting processes required in liquid electrolytes that use solvents. Furthermore, the polymer electrolyte composition exhibits high dispersibility despite the absence of solvent, and since there is no residual solvent even after the polymer electrolyte is prepared, there is no side reaction or structural decay of the electrode material when used on the electrode.

The liquid monomer refers to a monomer having a melting point (M.P.) at room

temperature or higher at normal pressure, and by using the liquid monomer, it is possible to prepare a solvent-free polymer electrolyte composition, and the ionic conductivity is significantly improved by increasing the uniformity inside the polymer electrolyte composition and inside the electrode despite being solvent-free.

5 Furthermore, the polymer-based electrolyte composition of the invention is wherein said lithium salt is included in an excess amount over said liquid monomer, wherein an excess amount means that said lithium salt is included in a greater weight relative to said liquid monomer.

 More specifically, with respect to said 100 parts by weight of liquid monomer, said lithium salt may comprise from 120 to 350 parts by weight, preferably from 130 to 300 parts by weight,
10 more preferably from 150 to 250 parts by weight, and most preferably from 180 to 220 parts by weight.

 If the weight ratio of the above lithium salt to the above liquid monomer 100 weight part is less than the above lower limit, the potential window of the polymer electrolyte utilizing the lithium salt is not wide enough, and it may be difficult to expect high efficiency in high-voltage
15 operation; on the other hand, if the above upper limit is exceeded, the lithium salt may not dissociate, and it may be difficult to play a role as an electrolyte, and the adhesion may deteriorate rapidly.

 The liquid monomer may comprise at least one functional group selected from the group consisting of carbonyl groups, amine groups, epoxy, phenolic, urethane and acrylate groups,
20 preferably at least one functional group selected from the group consisting of epoxy, phenolic, urethane and acrylate groups, more preferably at least one functional group selected from the group consisting of carboxyl groups in the acrylate series, and most preferably the liquid monomer may be acrylic acid.

Specific examples of liquid monomers containing epoxy groups include Bisphenol A, Bisphenol F, Novalac, and Glycidyl Amine.

Specific examples of liquid monomers containing phenolic groups include Novolak and Resol.

5 Specific examples of liquid monomers containing urethane groups include polyether polyols, polyester polyols, and isocyanates.

Specific examples of liquid monomers containing acrylate groups include methyl methacrylate, acrylonitrile, and acrylic acid.

10 If the liquid monomer contains an acrylate group, it is more durable and stable due to less change in physical properties due to hydrogen bonding between monomers due to the presence of -OH groups, lightweight due to low density, and easy to manufacture in various shapes due to increased processability. Furthermore, it is recyclable and has the advantage of being an environmentally friendly material. In particular, if the liquid monomer is acrylic acid, it is more preferable in that it exhibits better stability due to less viscosity change due to long-term storage
15 and temperature change.

 If said liquid monomer comprises urethane groups, it is preferable in that it has strong cohesion and thus excellent durability.

 If the liquid monomer is a liquid monomer comprising a phenolic group, it is preferable in that it has a large retention rate of strength even when used at high temperatures for a long time
20 and excellent flame retardancy.

 Examples of the above lithium salts include but are not limited to at least one selected from LiBOB, LiFOB, LiDFBP, Li(CF₃SO₂)₂, Li(CF₃SO₂)₂CH, Li(CF₃SO₂)₃C, LiCF₃(CF₂)₇SO₃, LiCF₃SO₃, LiCF₃CF₂SO₃, LiTFO, LiClO₄, LiSbF₆, LiAsF₆, LiPF₆, Li(CF₃)₂PF₄, Li(CF₃)₃PF₃,

$\text{Li}(\text{CF}_3)_4\text{PF}_2$, $\text{Li}(\text{CF}_3)_5\text{PF}$, $\text{Li}(\text{CF}_3)_6\text{P}$, LiCTFSI ($\text{LiN}(\text{C}_2\text{F}_4\text{S}_2\text{O}_4)$), LiBETI ($\text{LiC}_4\text{NO}_4\text{F}_{10}\text{S}_2$), LiFSI ($\text{LiNO}_4\text{F}_2\text{S}_2$) and LiTFSI ($\text{LiC}_2\text{NO}_4\text{F}_6\text{S}_2$).

When said lithium salt is at least one species selected from the group consisting of LiBOB , LiFOB , and LiDFBP , it is preferred in that the SEI interface formation leading to stable lithium electrodeposition is more robustly formed, and the interface is maintained in its initial shape even under high voltage conditions.

If said lithium salt is at least one species selected from the group consisting of $\text{Li}(\text{CF}_3\text{SO}_2)_2$, $\text{Li}(\text{CF}_3\text{SO}_2)_2\text{CH}$, $\text{Li}(\text{CF}_3\text{SO}_2)_3\text{C}$, LiCF_3 (CF_2) $_7\text{SO}_3$, LiCF_3SO_3 , and $\text{LiCF}_3\text{CF}_2\text{SO}_3$, it is preferred in that it is chemically safe and side reactions are avoided.

It is preferred if said lithium salt is at least one species selected from the group consisting of LiTFO , LiClO_4 , LiSbF_6 , LiAsF_6 , LiPF_6 , $\text{Li}(\text{CF}_3)_2\text{PF}_4$, $\text{Li}(\text{CF}_3)_3\text{PF}_3$, $\text{Li}(\text{CF}_3)_4\text{PF}_2$, $\text{Li}(\text{CF}_3)_5\text{PF}$, and $\text{Li}(\text{CF}_3)_6\text{P}$, in that it exhibits excellent lithium dissociation performance even when subjected to repeatedly drastic changes in temperature.

When said lithium salt is at least one selected from the group consisting of LiCTFSI ($\text{LiN}(\text{C}_2\text{F}_4\text{S}_2\text{O}_4)$), LiBETI ($\text{LiC}_4\text{NO}_4\text{F}_{10}\text{S}_2$), LiFSI ($\text{LiNO}_4\text{F}_2\text{S}_2$), and LiTFSI ($\text{LiC}_2\text{NO}_4\text{F}_6\text{S}_2$), the dissociation of the lithium salt is further induced due to the delocalization of the anionic charge, thereby improving the ionic conductivity properties and inducing the formation of a stable SEI interface based on LIF. Furthermore, when the liquid monomer is a monomer comprising an acrylate group, it is preferable in that the acrylate OH and the F of the lithium salt form a hydrogen bond, thereby significantly facilitating the dissociation of the lithium ions.

According to a preferred one embodiment of the present invention, the combination of said liquid monomer; and said lithium salt; The combination (liquid monomer, lithium salt) may be at least one selected from the group consisting of (bisphenol A, LiBETI), (bisphenol F, LiFSI),

(polyester polyol, LiTFSI), (Novalak, LiFSI), (polyether polyol, LiBETI), and (acrylic acid, LiTFSI).

When the combination of said liquid monomer; and said lithium salt is (bisphenol A, LiBETI), the rate of increase of the electrode-active material interfacial layer thickness can be significantly reduced after a secondary cell comprising the same is charged and discharged at a high voltage for a long period of time.

When the combination of said liquid monomer; and said lithium salt; is (bisphenol F, LiFSI), the mechanical properties of the secondary cell comprising it may not deteriorate at all from the initial one even after prolonged charge and discharge at high voltage.

When the combination of said liquid monomer; and said lithium salt; is (polyester polyol, LiTFSI), the secondary cell comprising the same may not experience any desorption of active material from the collector even after long-term charge and discharge.

When the combination of said liquid monomer; and said lithium salt; is (polyether polyol, LiBETI), a secondary cell comprising the same may not develop cracks in the electrode active material even after long-term charge and discharge.

When the combination of said liquid monomer; and said lithium salt; is (acrylic acid, LiTFSI), even if an electrode with a large thickness is prepared and utilized in a secondary cell using the same, the amount of decrease in capacity expression of the secondary cell comprising said electrode can be alleviated because the ion network is well formed.

Another aspect of the present invention provides a polymer-based electrolyte prepared by crosslinking said polymer-based electrolyte composition.

The crosslinking may be performed by heat treatment or UV irradiation.

Another aspect of the present invention provides an electrode comprising: said polymer-

based electrolyte composition; and an electrode active material.

The electrode active material has a low binding capacity to the collector, making a binder essential in the manufacture of the electrode, but such a binder reduces the proportion of active material, resulting in the prior art electrodes not having high energization characteristics. The electrode of the present invention, on the other hand, provides a solvent-free composition for manufacturing a polymeric solid electrolyte comprising a liquid monomer and an excess of lithium salt, and an electrode comprising an electrode active material, thereby improving ionic conductivity and electrochemical properties without the risk of residual solvent, and enabling the electrode to exhibit high energization properties with excellent adhesion without the need for a binder.

FIG. 1 is a schematic illustration of a method of fabricating an electrode according to one embodiment of the present invention.

Referring to FIG. 1 above, it can be seen that the electrode of the present invention does not contain a binder, as the solvent-free composition for the preparation of polymer-based solid electrolytes exhibits binder properties based on high adhesion with the collector due to strong intermolecular interactions. As a result, the electrode using the solvent-free composition for preparing a polymer-based solid electrolyte according to the present invention can exhibit high energization characteristics by increasing the active material ratio due to the absence of a binder, and can exhibit eco-friendly characteristics by not using a conventional F-based binder. Furthermore, it can be seen that the polymer electrolyte composition acts as a passageway for ions in the electrode.

The electrode active material may comprise one or more species selected from the group consisting of LCO (LiCoO_2), NCM111 ($\text{LiNi}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3}\text{O}_2$), NCM622 ($\text{LiNi}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$),

NCM811 ($\text{LiNi}_{0.8}\text{Co}_{0.1}\text{Mn}_{0.1}\text{O}_2$), LMO (LiMn_2O_4), and LNMO ($\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$), most preferably may comprise NCM811 ($\text{LiNi}_{0.8}\text{Co}_{0.1}\text{Mn}_{0.1}\text{O}_2$).

The electrode slurry may further comprise a conductive material.

Said coating material may comprise at least one species selected from the group consisting of Super P, Super C, carbon black, Ketjenblack, natural graphite, artificial graphite, carbon black, acetylene black, lamp black, furnace black and summer black, most preferably Super P.

Based on 100 wt% of the total of said electrodes, said solvent-free polymeric solid electrolyte may comprise from 9 to 23 wt%, preferably from 12 to 22 wt%, more preferably from 14 to 21 wt%, most preferably from 15 to 20 wt%.

If the solvent-free polymeric solid electrolyte is included at a weight percentage below the lower limit, it may be difficult to fabricate a high-loading electrode, and conversely, if it is included at a weight percentage above the upper limit, the energy density may be reduced due to a decrease in the active material ratio.

Said electrode may comprise said electrode active material, said coating material and a solvent-free composition for the preparation of said polymeric solid electrolyte in a ratio of 70 to 90 : 1 to 7 : 9 to 23 parts by weight, preferably 72 to 87 : 1 to 6 : 12 to 22 parts by weight, more preferably 74 to 85 : 1 to 5 : 14 to 21 parts by weight, most preferably 76 to 83 : 2 to 4 : 15 to 20 parts by weight.

Preferably, the weight ratio of said electrode active material, said conductive material and said solvent-free composition for the preparation of said polymeric solid electrolyte in said electrode satisfies the above range, in that it is possible to fabricate an electrode for high energy density when the weight ratio of said electrode active material, said conductive material and said solvent-free composition for the preparation of said polymeric solid electrolyte satisfies the above

range.

In particular, the solvent-free compositions for the preparation of polymer-based solid electrolytes according to the present invention exhibit high adhesion to the collector due to strong intermolecular interactions and thus have binder properties. As a result, electrodes using the solvent-free composition for the preparation of polymer-based solid electrolytes according to the present invention can exhibit high energization characteristics by increasing the active material ratio due to the absence of binders, and exhibit eco-friendly characteristics by not using conventional F-based binders.

Another aspect of the present invention provides a cell comprising said polymer-based electrolyte composition or said electrode.

The battery may be a secondary cell, preferably a lithium secondary cell.

Another aspect of the present invention provides an apparatus comprising said secondary cell, wherein said apparatus is selected from the group consisting of a communication device, an energy storage system (ESS), and a transportation vehicle.

Another aspect of the present invention provides a method of preparing a polymer-based electrolyte comprising (A) mixing a liquid monomer and an excess of lithium salt to obtain a solvent-free composition for preparing a polymeric solid electrolyte; and (B) crosslinking said polymer-based electrolyte composition.

(A) mixing a liquid monomer and an excess of lithium salt to obtain a solvent-free composition for making a polymeric solid electrolyte

Step (A) above, wherein the liquid monomer and an excess of lithium salt are mixed to obtain a solvent-free composition for the preparation of a polymeric solid electrolyte.

In said step (A), said lithium salt is mixed in excess of said liquid monomer.

For said 100 parts by weight of liquid monomer, said lithium salt may be mixed in an amount of from 120 to 350 parts by weight, preferably from 130 to 300 parts by weight, more preferably from 150 to 250 parts by weight, and most preferably from 180 to 220 parts by weight.

If the weight ratio of the above lithium salt to the above liquid monomer 100 parts by weight is less than the above lower limit, the potential window of the polymer electrolyte finally prepared may not be wide enough, and it may be difficult to expect high efficiency in high-voltage operation; conversely, if the above upper limit is exceeded, the lithium salt may not dissociate and cannot be expected to act as an electrolyte.

The liquid monomer may comprise at least one functional group selected from the group consisting of carbonyl groups, amine groups, epoxy, phenolic, urethane and acrylate groups, preferably at least one functional group selected from the group consisting of epoxy, phenolic, urethane and acrylate groups, more preferably at least one functional group selected from the group consisting of carboxyl groups in the acrylate series, and most preferably the liquid monomer may be acrylic acid.

Examples of the above lithium salts include but are not limited to at least one selected from LiBOB, LiFOB, LiDFBP, $\text{Li}(\text{CF}_3\text{SO}_2)_2$, $\text{Li}(\text{CF}_3\text{SO}_2)_2\text{CH}$, $\text{Li}(\text{CF}_3\text{SO}_2)_3\text{C}$, $\text{LiCF}_3(\text{CF}_2)_7\text{SO}_3$, LiCF_3SO_3 , $\text{LiCF}_3\text{CF}_2\text{SO}_3$, LiTFO, LiClO_4 , LiSbF_6 , LiAsF_6 , LiPF_6 , $\text{Li}(\text{CF}_3)_2\text{PF}_4$, $\text{Li}(\text{CF}_3)_3\text{PF}_3$, $\text{Li}(\text{CF}_3)_4\text{PF}_2$, $\text{Li}(\text{CF}_3)_5\text{PF}$, $\text{Li}(\text{CF}_3)_6\text{P}$, LiCTFSI ($\text{LiN}(\text{C}_2\text{F}_4\text{S}_2\text{O}_4)$), LiBETI ($\text{LiC}_4\text{NO}_4\text{F}_{10}\text{S}_2$), LiFSI ($\text{LiNO}_4\text{F}_2\text{S}_2$) and LiTFSI ($\text{LiC}_2\text{NO}_4\text{F}_6\text{S}_2$).

According to a preferred one embodiment of the present invention, the combination of said liquid monomer; and said lithium salt; The combination (liquid monomer, lithium salt) may be at least one selected from the group consisting of (bisphenol A, LiBETI), (bisphenol F, LiFSI), (polyester polyol, LiTFSI), (Novalak, LiFSI), (polyether polyol, LiBETI), and (acrylic acid,

LiTFSI).

(B) crosslinking said polymer-based electrolyte composition;

The step (B) wherein said polymer-based electrolyte composition is crosslinked to produce a polymer-based electrolyte.

5 The crosslinking may be performed by heat treatment or UV irradiation.

Said heat treatment may be carried out at 50 to 90 °C for 0.8 to 4 hours, preferably at 55 to 85 °C for 1 to 3 hours, more preferably at 57 to 82 °C for 1.5 to 2.5 hours, most preferably at 60 to 80 °C for 1.8 to 2.3 hours.

10 If any of the above heat treatment temperatures and times are below the lower limit, thick film electrode fabrication may be difficult, and conversely, if they are above the upper limit, degradation of the components in the electrode may occur.

Said UV irradiation may be performed by irradiating with UV for 0.1 to 6 minutes, preferably 0.2 to 3 minutes, more preferably 0.3 to 2.5 minutes, most preferably 0.5 to 1.5 minutes.

15 If the UV irradiation time is less than the lower limit of 0.1 minutes, not enough cross-linking may occur, and if the upper limit of 6 minutes is exceeded, cross-linking may be complete and no further cross-linking may occur, which will only increase the cost.

Where said crosslinking is performed by UV irradiation, said solvent-free composition for the preparation of a polymeric solid electrolyte may further comprise a photoinitiator.

20 The photoinitiator may be one or more selected from the group consisting of 2-hydroxy-2-methylpropiophenone (HMPP), 2,4,6-trimethyl benzoyl diphenyl phosphine (TPO), and benzildimethylketal (BDK).

Said photoinitiator may be 1.3 to 2 parts by weight, preferably 1.5 to 1.8 parts by weight, more preferably 1.6 to 1.7 parts by weight, most preferably 1.64 to 1.68 parts by weight, based on

a total of 100 parts by weight of said liquid monomer and said lithium salt.

If said photoinitiator is less than said lower limit with respect to a total of 100 parts by weight of said liquid monomer and said lithium salt, crosslinking may not occur sufficiently, and if it is more than said upper limit, crosslinking may be complete and no further crosslinking may occur, which only increases the cost.

Another aspect of the present invention provides a method of preparing an electrode, comprising (I) mixing a liquid monomer and an excess of lithium salt to obtain a solvent-free composition for preparing a polymeric solid electrolyte; (II) mixing an electrode active material and said polymeric solid electrolyte solvent-free composition to prepare an electrode slurry; and (III) crosslinking said electrode slurry to prepare an electrode.

In the manufacturing method of the electrode of the present invention, the contents of the polymer electrolyte composition which are deemed to be the same as those described above are omitted from the following detailed description.

For said 100 parts by weight of liquid monomer, said lithium salt may be mixed in an amount of from 120 to 350 parts by weight, preferably from 130 to 300 parts by weight, more preferably from 150 to 250 parts by weight, most preferably from 180 to 220 parts by weight.

The liquid monomer may comprise at least one functional group selected from the group consisting of carbonyl groups, amine groups, epoxy, phenolic, urethane and acrylate groups, preferably at least one functional group selected from the group consisting of epoxy, phenolic, urethane and acrylate groups, more preferably at least one functional group selected from the group consisting of carboxyl groups in the acrylate series, and most preferably the liquid monomer may be acrylic acid.

Examples of the above lithium salts include but are not limited to LiBOB, LiFOB,

LiDFBP, $\text{Li}(\text{CF}_3\text{SO}_2)_2$, $\text{Li}(\text{CF}_3\text{SO}_2)_2\text{CH}$, $\text{Li}(\text{CF}_3\text{SO}_2)_3\text{C}$, $\text{LiCF}_3(\text{CF}_2)_7\text{SO}_3$, LiCF_3SO_3 , $\text{LiCF}_3\text{CF}_2\text{SO}_3$, LiTFO, LiClO_4 , LiSbF_6 , LiAsF_6 , LiPF_6 , $\text{Li}(\text{CF}_3)_2\text{PF}_4$, $\text{Li}(\text{CF}_3)_3\text{PF}_3$, $\text{Li}(\text{CF}_3)_4\text{PF}_2$, $\text{Li}(\text{CF}_3)_5\text{PF}$, $\text{Li}(\text{CF}_3)_6\text{P}$, LiCTFSI ($\text{LiN}(\text{C}_2\text{F}_4\text{S}_2\text{O}_4)$), LiBETI ($\text{LiC}_4\text{NO}_4\text{F}_{10}\text{S}_2$), LiFSI ($\text{LiNO}_4\text{F}_2\text{S}_2$), and LiTFSI ($\text{LiC}_2\text{NO}_4\text{F}_6\text{S}_2$).

5 According to a preferred one embodiment of the present invention, the combination of said liquid monomer; and said lithium salt; The combination (liquid monomer, lithium salt) may be at least one selected from the group consisting of (bisphenol A, LiBETI), (bisphenol F, LiFSI), (polyester polyol, LiTFSI), (Novalak, LiFSI), (polyether polyol, LiBETI), and (acrylic acid, LiTFSI).

10 The electrode active material may comprise one or more species selected from the group consisting of LCO (LiCoO_2), NCM111 ($\text{LiNi}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3}\text{O}_2$), NCM622 ($\text{LiNi}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$), NCM811 ($\text{LiNi}_{0.8}\text{Co}_{0.1}\text{Mn}_{0.1}\text{O}_2$), LMO (LiMn_2O_4) 및 LNMO ($\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$), most preferably NCM811 NCM811 ($\text{LiNi}_{0.8}\text{Co}_{0.1}\text{Mn}_{0.1}\text{O}_2$).

The electrode slurry may further comprise a conductive material.

15 Said coating material may comprise at least one species selected from the group consisting of Super P, Super C, carbon black, Ketjenblack, natural graphite, artificial graphite, carbon black, acetylene black, lamp black, furnace black and summer black, most preferably Super P.

Based on a total of 100 wt% of said electrode slurry, said solvent-free composition for the preparation of a polymeric solid electrolyte may comprise from 9 to 23 wt%, preferably from 12 to 22 wt%, more preferably from 14 to 21 wt%, most preferably from 15 to 20 wt%.

20

If the solvent-free composition for the preparation of the polymeric solid electrolyte is included in a weight percentage below the lower limit, it may be difficult to fabricate a dry thick film electrode for high energization, and conversely, if it is included in a weight percentage above

the upper limit, a decrease in energy density may occur due to a decrease in the proportion of active material.

Said electrode slurry may comprise said electrode active material, said coating material and a solvent-free composition for the preparation of said polymeric solid electrolyte in a ratio of
5 70 to 90 : 1 to 7 : 9 to 23 parts by weight, preferably 72 to 87 : 1 to 6 : 12 to 22 parts by weight, more preferably 74 to 85 : 1 to 5 : 14 to 21 parts by weight, most preferably 76 to 83 : 2 to 4 : 15 to 20 parts by weight.

Preferably, said electrode slurry satisfies the above range, in that if the weight ratio of said electrode active material, said conductive material and said solvent-free composition for making
10 said polymeric solid electrolyte satisfies the above range, dry thick film electrode fabrication for high energization is possible.

The crosslinking in step (III) above may be performed by heat treatment or UV irradiation.

Said heat treatment may be carried out at 50 to 90 °C for 0.8 to 4 hours, preferably at 55 to 85 °C for 1 to 3 hours, more preferably at 57 to 82 °C for 1.5 to 2.5 hours, most preferably at
15 60 to 80 °C for 1.8 to 2.2 hours.

When the cross-linking of (III) above is performed by heat treatment, if any of the heat treatment temperature and time is below the lower limit of the above, it may be difficult to produce a thick film electrode, and conversely, if the upper limit of the above is exceeded, decomposition of the components in the electrode may occur.

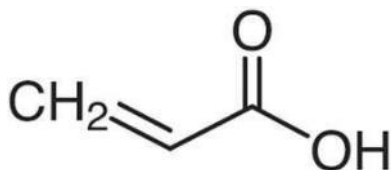
20 The present invention will be described in more detail below by way of examples, and the scope and content of the present invention should not be construed to be reduced or limited by the following examples.

Example 1 (Monomer + Excess Lithium Salt + Solvent-free, MIS)

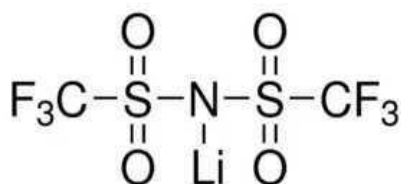
Preparation of Polymer Electrolyte

Without using a solvent, a solvent-free composition for the preparation of a polymer-based solid electrolyte was prepared by mixing a monomer (acrylic acid, Formula 1) and a lithium salt (LiTFSI, lithium bis(trifluoromethanesulfonyl)imide, Formula 2) in a 1:2 weight ratio and adding a photoinitiator 2-Hydroxy-2-methylpropiophenon (HMPP) in an amount equal to 0.05 weight of the monomer. The polymeric solid electrolyte composition in solution was then cast onto a nonwoven fabric surface. Then, the polymer electrolyte composition coated on the nonwoven fabric was subjected to UV (365 nm, 2000 mW/cm²) crosslinking for 1 minute to polymerize the crosslinking monomer to prepare the polymer electrolyte.

[Formula 1].



[Formula 2].



Electrode Manufacturing

An electrode slurry was prepared by mixing the cathode active material (NCM811, LLO) / coating material (Super P) / solvent-free composition for the preparation of the above polymer-based solid electrolyte in a weight ratio of 80:3:17. Then, the electrode slurry was cast onto the Al electrode, and the electrode was prepared by thermal crosslinking at 70 °C for 2 hours.

FIG. 2 is a simplified schematic illustration of an electrode fabricated in an Example of the present invention.

Referring to FIG. 2 above, an electrode comprising the solvent-free polymeric solid electrolyte (MIS) composition was formed on the Al electrode.

Example 2

The molecular electrolyte and electrode were prepared as in Example 1 above, except that
5 the monomer and lithium salt were mixed in a weight ratio of 1 : 1.4.

Example 3

The molecular electrolyte and electrode were prepared as in Example 1 above, except that the monomer and lithium salt were mixed in a weight ratio of 1 : 4.

Comparative Examples 1 to 3 (excess monomer + lithium salt + solvent-free)

10 The polymer electrolyte and electrode were prepared as in Example 1 above, except that the monomer (acrylic acid) and lithium salt (LiTFSI) were changed to 4:1 (Comparative Example 1), 2:1 (Comparative Example 2), and 1:1 (Comparative Example 3).

Comparative Example 4 (polymer + excess lithium salt + solvent-free, PIS)

The polymer electrolyte and electrode were prepared as in Example 1 above, but using
15 poly-Acrylic acid rather than acrylic acid monomer.

Comparative Example 5 (monomer + excess lithium salt + solvent)

The polymer electrolyte and electrode were prepared as in Example 1 above, except that the polymer electrolyte and electrode were prepared by including 10 parts by weight of N,N-Dimethylformamide (DMF) as a solvent for a total of 100 parts by weight of the polymer
20 electrolyte composition.

Example 1. Evaluation of lithium ion conduction performance as a function of monomer and lithium salt mix ratio

The ionic conductivity of the polymer electrolytes prepared in Example 1 and

Comparative Examples 1 to 3 above was evaluated, and the results are shown in FIG. 3.

FIG. 3 shows the ionic conductivity and activation energy of the polymer-based electrolytes prepared in Example 1 (1/2), Comparative Example 1 (4/1), Comparative Example 2 (2/1), and Comparative Example 3 (1/1) of the present invention.

5 Referring to FIG. 3 above, it can be seen that the ionic conductivity of Example 1 (1/2), Comparative Example 1 (4/1), Comparative Example 2 (2/1), and Comparative Example 3 (1/1) is 0.158, 0.0552, 0.0711, and 0.0819 mS/cm, respectively, at 60 degrees C., indicating that the ionic conductivity is significantly improved in the polymer electrolyte of the present invention. Furthermore, the activation energies for the lithium conduction behavior of Example 1 (1/2),
10 Comparative Example 1 (4/1), Comparative Example 2 (2/1), and Comparative Example 3 (1/1) are 0.25, 0.32, 0.3, and 0.29 eV, respectively, indicating that the lithium conduction behavior is significantly improved in the polymer electrolyte of the present invention.

Example 2. Evaluation of lithium ion conduction performance as a function of monomer and lithium salt mix ratio

15 The adhesion and oxidation stability of the polymer-based electrolytes and electrodes prepared in Example 1 and Comparative Examples 1 to 4 above were evaluated, and the results are shown in FIG. 4 and Table 1 below.

In FIG. 4 above and Table 1 below, PEO, PVdF, and PAA are used as polymer-based electrolytes, respectively.

20 The adhesion was evaluated by the peel-off test method.

The oxidation stability was evaluated by the linear sweep voltammetry (LSV) method.

FIG. 4 shows the results of the oxidation stability and adhesion force evaluations of the polymer electrolyte and electrodes prepared in Example 1 (MIS, 1/2), Comparative Example 1

(4/1), Comparative Example 2 (2/1), Comparative Example 3 (1/1), and Comparative Example 4 (PIS) of the present invention and the electrodes using PEO, PVdF, and PAA.

[Table 1]

Separation	Oxidation Stability (vs Li/Li) ⁺	Adhesion (N cm) ⁻¹
Example 1 (MIS, 1/2)	5.3	0.53
Comparative Example 1 (4 of 1)	4.8	0.91
Comparative Example 2 (2/1)	4.95	0.77
Comparative Example 3 (1/1)	5.1	0.55
Comparative Example 4 (PIS)	5	0.33
PEO	4.52	0.29
PVdF	-.	0.53
PAA	-.	1.63

Referring to FIG. 4 and Table 1 above, it can be seen that the polymer-based electrolyte (MIS, 1/2) prepared in Example 1 of the present invention exhibits excellent oxidation stability compared to Comparative Examples 1 to 4, which have a small or equal amount of lithium salt compared to the monomer, Comparative Example 4, which uses a polymer rather than a monomer, and PEO, PVdF, and PAA used as conventional polymer-based electrolytes, and exhibits adhesion comparable to PVdF.

Example 3. Evaluation of Li-ion conduction performance

The electrodes prepared in Example 1 (AA-based MIS) and Comparative Example 4 (PAA-based PIS) and the electrode using PEO as a polymer-based electrolyte (PEO-based PIS) were prepared under the following conditions and their electrochemical properties were evaluated,

and are shown in FIG. 5.

*Areal mass loading: 40 mg cm⁻²

*MIS = AA/LiTFSI= 1/2 (w/w)

*Electrode density: 3.2 g cm⁻³

5 *NCM811/Super P/MIS = 80/3/17 (w/w/w)

*Cut-off voltage: 3.0-4.3 V

*Operating temp.: 60 °C.

FIG. 5 shows the specific capacity and coulombic efficiency as a function of the number of cycles of the electrode prepared in Example 1 (AA-based MIS) and Comparative Example 4 (PAA-based PIS) of the present invention and the electrode utilizing PEO as a polymer-based electrolyte (PEO-based PIS).

Referring to FIG. 5 above, it can be seen that the electrode prepared in Example 1 of the present invention (AA-based MIS) maintained 77.4% of the initial amount of cost even after 80 cycles compared to the electrode prepared in Comparative Example 4 (PAA-based PIS) and the electrode utilizing PEO as a polymer-based electrolyte (PEO-based PIS), showing excellent capacity retention and cycle characteristics.

Furthermore, it was confirmed that the electrode prepared in Example 1 (AA-based MIS) of the present invention maintained the highest Coulombic efficiency in the present invention with 77.4, 54.5, and 62.3% after 80 cycles compared to the electrode prepared in Comparative Example 4 (PAA-based PIS) and the electrode using PEO as the polymer-based electrolyte (PEO-based PIS), respectively.

Example 4. Evaluation of storage characteristics

Using the electrodes prepared in Examples 1 to 3 and Comparative Examples 1 to 3 above,

the cells were prepared under the same conditions as in Experimental Example 3 above, and charge and discharge measurements were made between 3.0 and 4.2 V at a constant current density of 5.0 mA/cm². At this time, the discharge capacity before storage (60 °C) was measured, and the cell was charged to 4.2 V at a constant current density of 5.0 mA/cm² for 8 hours. After the charged test cell was stored for 20 days in a chamber adjusted to maintain 80 °C, the discharge capacity (60 °C) was measured between 3.0 and 4.2 V at a constant current density of 5.0 mA/cm², and the storage characteristics (%) were calculated as shown in Equation (1) below, and the results are shown in Table 2.

$$\text{Equation (1): } (\text{Discharge capacity after storage}) / (\text{Discharge capacity before storage}) * 100$$

[Table 2]

Separation	Storage attributes (%)
Example 1	98.2
Example 2	95.5
Example 3	94.2
Comparative Example 1	89.54
Comparative Example 2	91.38
Comparative Example 3	92.37

As shown in Table 2 above, it can be seen that Comparative Examples 1 to 3 with an excess of liquid monomer have lower storage properties and therefore lower stability compared to Examples 1 to 3.

In particular, the storage property was increased when the weight ratio of lithium salt to liquid monomer was 2 (Example 1) compared to 1.4 (Example 2), but the storage property was decreased in Example 3 when the weight ratio of lithium salt to liquid monomer was further

increased to 4, confirming that controlling the content of lithium salt to a certain range is an important factor to further improve the storage property.

Example 5. Evaluation of Electrode Thickness Variation

Using the electrodes prepared in Examples 1 to 3 above, the cells were prepared under the same conditions as in Experimental Example 3 above, and the charging range was set such that the state of charge (SOC) ranged from 0 to 95% at 60 °C, and the first cycle was charged at 0.1 C, the second cycle at 0.2 C, and the third cycle at 0.5 C from the third cycle to the 30th cycle. The change in electrode thickness from the initial state was then measured and expressed as a percentage in Table 3 below.

[Table 3]

Separation	Electrode Thickness Change (%)
Example 1	15.2
Example 2	14.7
Example 3	21.6

Referring to Table 3 above, it can be seen that the electrodes prepared in Examples 1 and 2 had a small thickness variation, while the electrodes prepared in Example 3 had an increased thickness variation.

Example 6. Temperature rise during overcharge

Using the electrodes prepared in Examples 1 to 3 and Comparative Examples 1 to 3 above, a battery was prepared under the same conditions as in Experimental Example 3 above, and a thermocouple was attached to the outer surface of the battery case. Then, after stabilizing the battery in a 25 °C constant temperature bath, the highest attained temperature of the battery when a constant current charge was applied until the battery voltage was 5.1 V (overcharged state) was

recorded, and the temperature increase (°C) from 25 °C was calculated. Then. The values calculated using the temperature rise of the battery using the electrode of Example 1 above as a reference (100%) are shown in Table 3 below.

[Table 4]

Separation	Temperature rise on overcharge (%)
Example 1	100
Example 2	128
Example 3	98
Comparative Example 1	141
Comparative Example 2	138
Comparative Example 3	135

5

As shown in Table 4 above, it can be seen that the embodiments using an excess of lithium salts have a lower rate of temperature increase compared to Comparative Examples 1 to 3 using an excess of monomer.

10 In addition, the temperature rise rate was lower in Example 1 and Example 3, and the effectiveness of suppressing the temperature rise in the case of overcharging was higher, and by comparing the results of Example 1 to 3 above, it can be seen that even if the ratio of lithium salt to monomer is excessive, there is a difference in the temperature rise rate depending on the specific weight ratio.

Example 7

15 Using the electrodes prepared in Example 1 and Comparative Example 5 above, the

electrochemical properties were evaluated in the same way as in Experimental Example 3 above, and the results are shown in FIG. 6.

FIG. 6 shows the results of the electrochemical characterization of the electrodes prepared in Example 1 and Comparative Example 5 of the present invention.

5 As shown in FIG. 6 above, the initial capacity of the electrode prepared in Example 1 is 197.7 mAh g⁻¹, while the initial capacity of the electrode prepared in Comparative Example 5 is 145.2 mAh g⁻¹, and the capacity of the electrode prepared in Comparative Example 5 is significantly lower, which is due to the induction of pores and inhomogeneity in the electrode during the drying process of DMF as solvent.

10

CLAIMS

What is claimed is:

Claim 1

A solvent-free composition for preparing a polymer-based solid electrolyte, which
5 composition comprises a liquid monomer and a lithium salt, wherein said lithium salt is comprised
from 120 to 350 parts by weight based on 100 parts by weight of said liquid monomer.

Claim 2

The solvent-free composition for preparing a polymeric solid electrolyte of claim 1,
10 wherein said liquid monomer comprises at least one functional group selected from the group
consisting of carbonyl groups, amine groups, epoxy groups, phenolic groups, urethane groups, and
acrylate groups.

Claim 3

15 The solvent-free composition for preparing a polymeric solid electrolyte of claim 1,
wherein the combination of said liquid monomer and said lithium salt is selected from the group
consisting of (bisphenol A, LiBETI), (bisphenol F, LiFSI), (polyester polyol, LiTFSI), (Novalak,
LiFSI), (polyether polyol, LiBETI), (acrylic acid, LiTFSI), and mixtures of two or more thereof.

20 Claim 4

A polymer-based electrolyte prepared by crosslinking the solvent-free composition for
preparing a polymeric solid electrolyte of claim 1.

Claim 5

A solvent-free composition for preparing a cathode, which comprises a liquid monomer, lithium salt, cathode active material, and a coating material, wherein said lithium salt comprises from 120 to 350 parts by weight of said liquid monomer relative to 100 parts by weight of said
5 lithium salt.

Claim 6

The solvent-free composition for preparing cathodes of claim 5, wherein said liquid monomer comprises at least one functional group selected from the group consisting of carbonyl
10 groups, amine groups, epoxy groups, phenolic groups, urethane groups, and acrylate groups.

Claim 7

The solvent for preparing cathode of claim 5, wherein the combination of said liquid monomer and said lithium salt, is selected from the group consisting of (bisphenol A, LiBETI),
15 (bisphenol F, LiFSI), (polyester polyol, LiTFSI), (Novalak, LiFSI), (polyether polyol, LiBETI), (acrylic acid, LiTFSI), and mixtures of two or more thereof.

Claim 8

A cathode prepared by crosslinking a solvent-free composition for making a cathode
20 according to claim 5.

Claim 9

A secondary cell comprising (a) a polymer-based electrolyte of claim 4, (b) a cathode

prepared by crosslinking a solvent-free composition comprising a liquid monomer, lithium salt, cathode active material, and a coating material, wherein said lithium salt comprises from 120 to 350 parts by weight of said liquid monomer relative to 100 parts by weight of said lithium salt, or (c) both.

5

Claim 10

A process of preparing a polymer-based electrolyte, the process comprising:

(A) obtaining a solvent-free composition for preparing a polymeric solid electrolyte, the composition comprising a liquid monomer and a lithium salt; and

10 (B) crosslinking said liquid monomer,

wherein said lithium salt is from 120 to 350 parts by weight relative to said liquid monomer of 100 parts by weight.

Claim 11

15 The process of preparing the polymer-based electrolyte of claim 10, wherein said liquid monomer comprises at least one functional group selected from the group consisting of carbonyl groups, amine groups, epoxy groups, phenolic groups, urethane groups, and acrylate groups.

Claim 12

20 The process of preparing a polymer-based electrolyte of claim 10, wherein the combination of said liquid monomer and said lithium salt is any one of (bisphenol A, LiFSI), (bisphenol F, LiFSI), (polyester polyol, LiTFSI), (Novalak, LiFSI), (polyether polyol, LiBETI), and (acrylic acid, LiTFSI).

Claim 13

A process of preparing a cathode, the process comprising:

(A) obtaining a solvent-free composition for preparing cathodes, the composition

5 comprising a liquid monomer, a lithium salt, a cathode active material, and a coating material;

(B) coating said composition onto a substrate; and

(C) crosslinking said composition,

wherein said lithium salt is from 120 to 350 parts by weight relative to said liquid
monomer of 100 parts by weight.

10

Claim 14

The process of claim 13, wherein said liquid monomer comprises at least one functional
group selected from the group consisting of carbonyl groups, amine groups, epoxy groups,
phenolic groups, urethane groups, and acrylate groups.

15

Claim 15

The process of claim 13, wherein the combination of said liquid monomer and said lithium
salt is any one of (bisphenol A, LiFSI), (bisphenol F, LiFSI), (polyester polyol, LiTFSI), (Novalak,
LiFSI), (polyether polyol, LiBETI), and (acrylic acid, LiTFSI).

20

ABSTRACT

The present invention relates to a solvent-free composition for making a polymer-based solid electrolyte, an electrode using the composition, and a method for making the composition.

The polymer electrolyte composition according to the present invention can exhibit excellent

5 dispersibility without a process solvent, can solve problems caused by residual solvent, and can exhibit high oxidative stability.

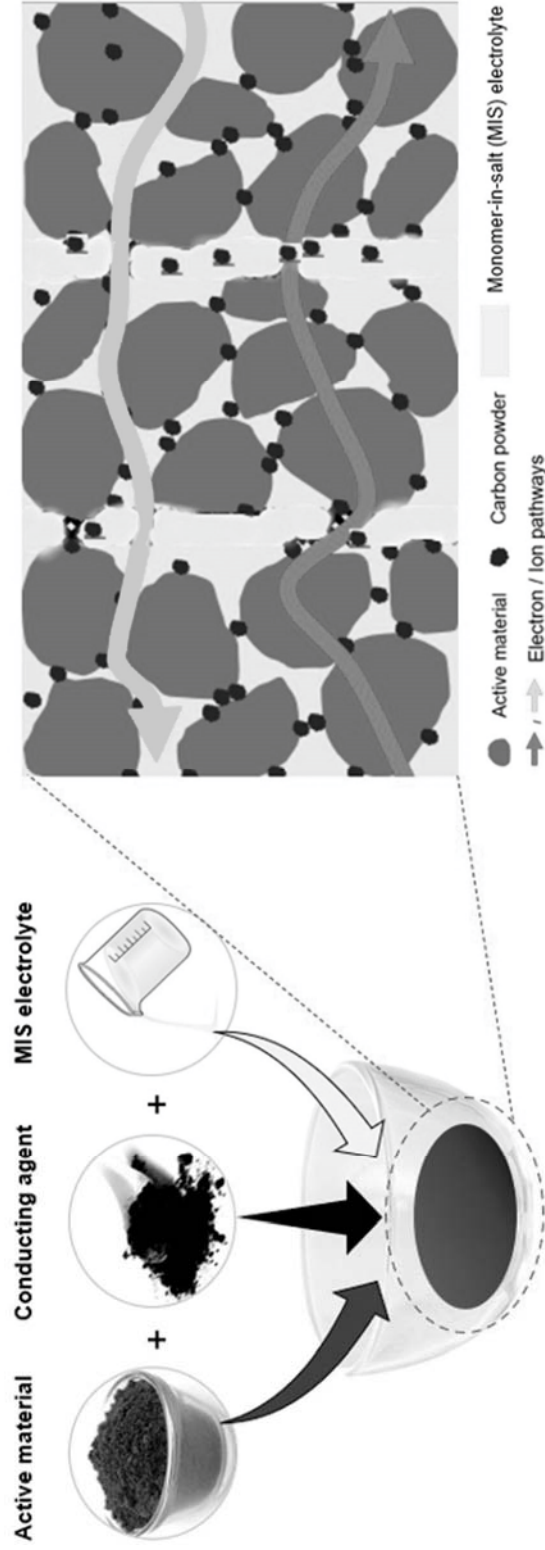


FIG. 1

FIG. 2

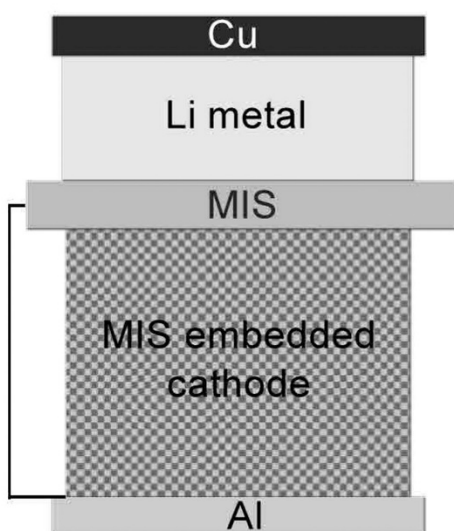


FIG. 3

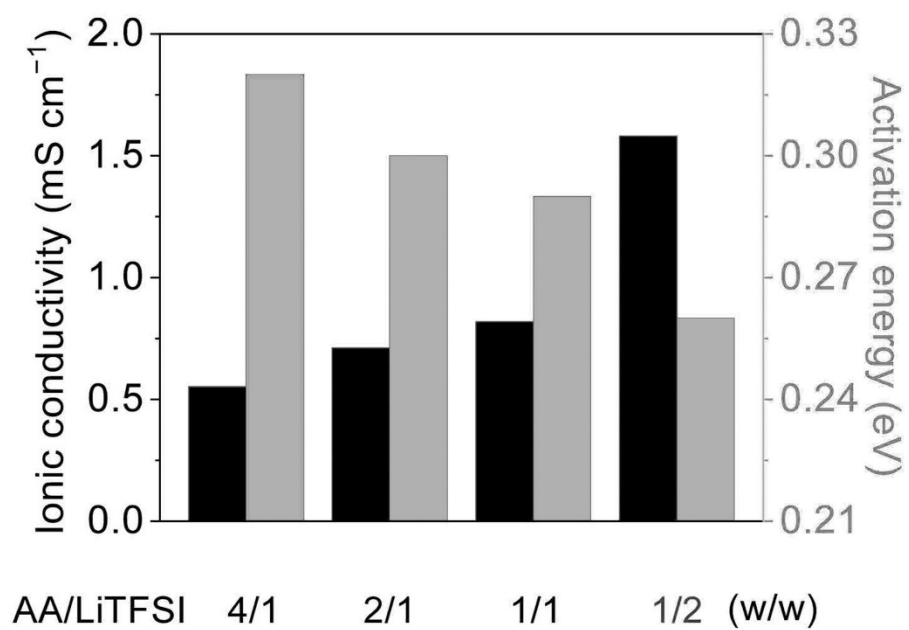
Li⁺ conduction behavior

FIG. 4

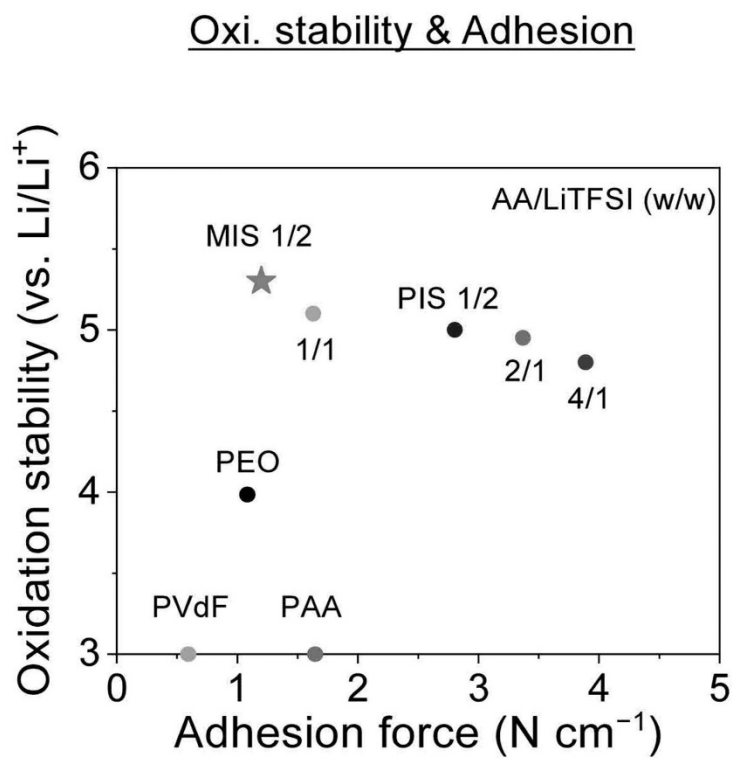


FIG. 5

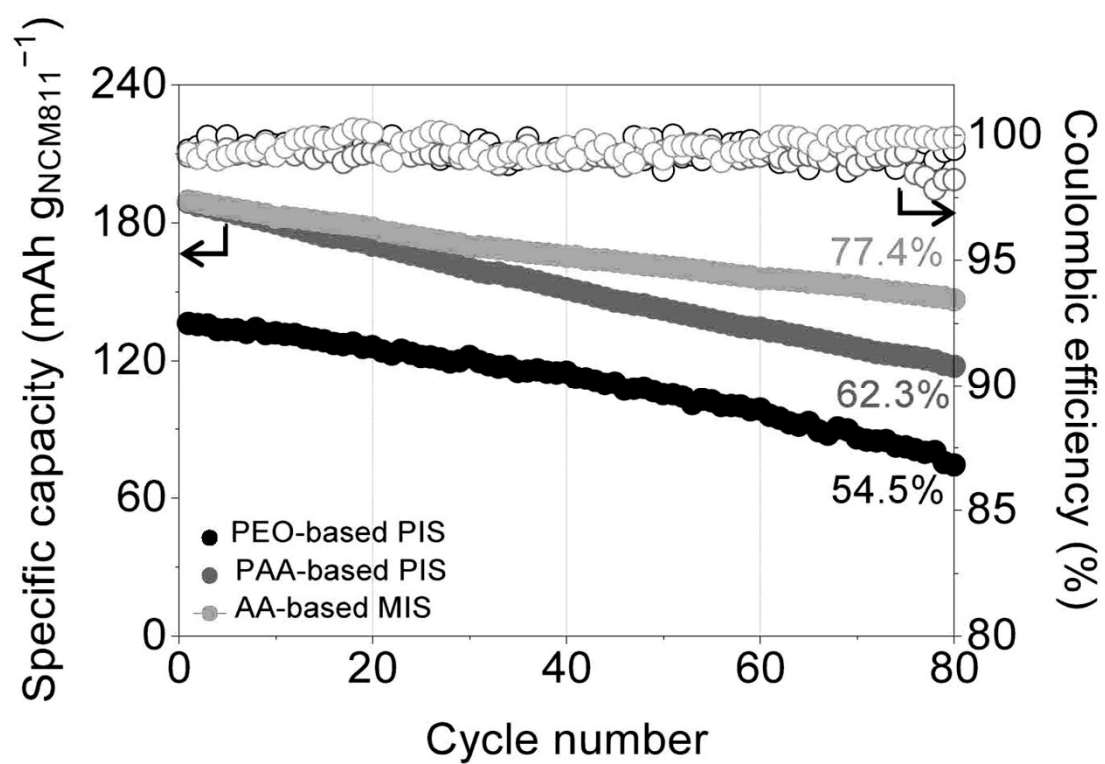
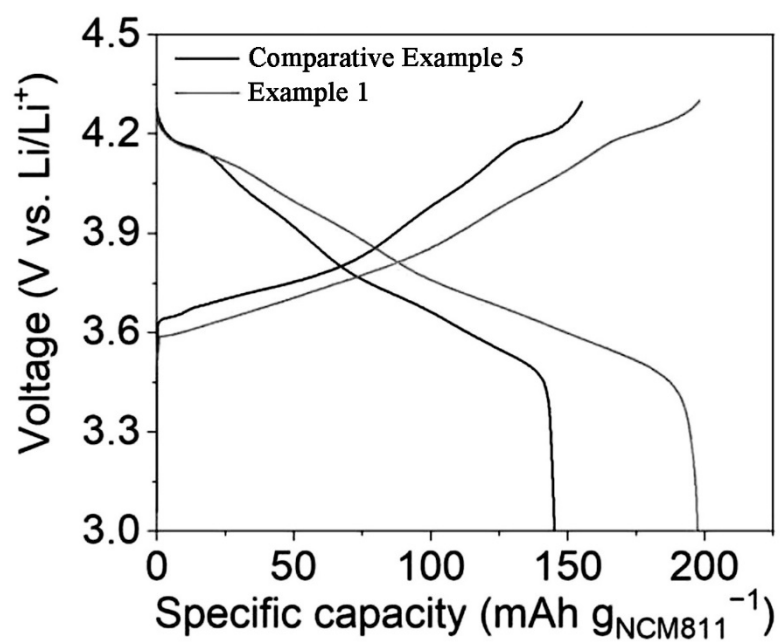


FIG. 6



INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number			
	Filing Date		2024-11-15	
	First Named Inventor	Sang-Young LEE		
	Art Unit	TBD		
	Examiner Name	TBD		
	Attorney Docket Number	G1035-29701		

U.S.PATENTS						
Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button.

U.S.PATENT APPLICATION PUBLICATIONS						
Examiner Initial*	Cite No	Publication Number	Kind Code ¹	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button.

FOREIGN PATENT DOCUMENTS								
Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ²	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T ⁵
	1	2023/002015	WO		2022-07-22	NICOLÁS AGUADO		<input type="checkbox"/>
	2	102567762	KR		2023-08-16	JEONG		<input type="checkbox"/>

If you wish to add additional Foreign Patent Document citation information please click the Add button

NON-PATENT LITERATURE DOCUMENTS								
---------------------------------	--	--	--	--	--	--	--	--

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		
	Filing Date		2024-11-15
	First Named Inventor	Sang-Young LEE	
	Art Unit	TBD	
	Examiner Name	TBD	
	Attorney Docket Number	G1035-29701	

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
	1	KIM, S., et al., "The effect of inorganic nanoparticles on ion conduction in poly(lithium acrylate)-based composite polymer electrolytes for energy storage devices", Molecular Crystals and Liquid Crystals, Vol. 742, No. 1, pp. 103-110.	<input type="checkbox"/>
	2	LIU, W., et al., "Designing Polymer-in-Salt Electrolyte and Fully Infiltrated 3D Electrode for Integrated Solid-State Lithium Batteries", Angewandte Chemie International Edition, June 1, 2021, Vol. 60, Issue 23, pp. 12931-12940	<input type="checkbox"/>

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature		Date Considered	
--------------------	--	-----------------	--

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number			
Filing Date		2024-11-15	
First Named Inventor	Sang-Young LEE		
Art Unit	TBD		
Examiner Name	TBD		
Attorney Docket Number	G1035-29701		

CERTIFICATION STATEMENT

Please see 37 CFR 1.97(e) to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

- ☐ See attached certification statement.
- ☒ A certification statement is not submitted herewith.

FEE

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

COPIES

☐ An identification of an earlier application pursuant to 37 CFR 1.98 (d) (1) is attached.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Gregory M. Lefkowitz/	Date (YYYY-MM-DD)	2024-11-15
Name/Print	Gregory M. Lefkowitz	Registration Number	56,216

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**