

PATENT ASSIGNMENT COVER SHEET

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SUBMISSION TYPE:	NEW ASSIGNMENT										
NATURE OF CONVEYANCE:	ASSIGNMENT										
CONVEYING PARTY DATA											
<table border="1"><thead><tr><th>Name</th><th>Execution Date</th></tr></thead><tbody><tr><td>Sang-Young LEE</td><td>06/26/2025</td></tr><tr><td>Soohyoung LEE</td><td>06/26/2025</td></tr><tr><td>Kyeong-Seok OH</td><td>06/26/2025</td></tr></tbody></table>	Name	Execution Date	Sang-Young LEE	06/26/2025	Soohyoung LEE	06/26/2025	Kyeong-Seok OH	06/26/2025			
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<table border="1"><tr><td>Name:</td><td>UIF (UNIVERSITY IND USTRY FOUNDATION), YONSEI UNIVERSITY</td></tr><tr><td>Street Address:</td><td>50 Yonsei-ro, Seodaemun-gu</td></tr><tr><td>City:</td><td>Seoul</td></tr><tr><td>State/Country:</td><td>KOREA, REPUBLIC OF</td></tr><tr><td>Postal Code:</td><td>03722</td></tr></table>	Name:	UIF (UNIVERSITY IND USTRY FOUNDATION), YONSEI UNIVERSITY	Street Address:	50 Yonsei-ro, Seodaemun-gu	City:	Seoul	State/Country:	KOREA, REPUBLIC OF	Postal Code:	03722	
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**ELECTRONIC ACKNOWLEDGEMENT RECEIPT**APPLICATION #
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606100-000005**Title of Invention**

CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF THE SAME

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	1461	FILED BY	Jo-lin Hsieh
PATENT CENTER #	71121953	FILING DATE	-
CUSTOMER #	78198	FIRST NAMED INVENTOR	Sang-Young LEE
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Sang Yoon Kang

Documents**TOTAL DOCUMENTS: 9**

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
specification-APP.TEXT.docx	32	Application body structured text document	262 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. The abstract should be in narrative form and generally limited to a single paragraph preferably within the range of 50 to 150 words in length. See MPEP 608.01(b).			
drawings.pdf	6	Drawings-other than black and white line drawings	429 KB
ADS.pdf	9	Application Data Sheet	2174 KB
dec_asn.pdf	2	Oath or Declaration filed	505 KB
POA.pdf	2	Power of Attorney	136 KB

e-comm_auth.pdf	1	Internet Communications Authorization	49 KB
IDS.pdf	5	Information Disclosure Statement (IDS) Form (SB08)	1314 KB
KR10-1705393B1_FOR.pdf	69	Foreign Reference	8838 KB
specification.pdf	32	Auxiliary PDF of Application	470 KB

Digest

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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.

CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Korean Patent Application No. 10-2024-0085071 filed on June 28, 2024 and Korean Patent Application No. 10-2025-0084205 filed on June 25, 2025 and all the benefits accruing therefrom under 35 U.S.C. § 119, the contents of which are incorporated by reference in their entirety.

BACKGROUND

[0002] Lithium metal is attracting attention as a next-generation battery anode material due to its high theoretical capacity (3861 mAh g^{-1}) and low redox potential (-3.04 V vs. Standard hydrogen electrode). However, conventional liquid electrolytes are not well compatible with lithium metal anodes due to safety issues caused by high volatility and flammability, and liquid electrolytes are prone to depletion by continuously reacting with lithium metal anodes. Due to these problems, the transition to solid electrolytes for the use of lithium metal anodes is receiving significant attention. However, inorganic solid electrolytes represented by Argyrodite-type $\text{Li}_6\text{PS}_5\text{Cl}$ still have many unresolved problems such as low processability, poor interfacial contact, and reactivity with lithium metal.

[0003] As an alternative to this, polymer-based solid electrolytes, which have mild processing conditions and excellent compatibility with lithium metal, are being regarded as the most promising candidates as electrolytes for lithium metal batteries. However, most research on polymer electrolytes has focused on improving the low ionic conductivity compared to liquid

electrolytes and inorganic solid electrolytes, and studies dealing with interfacial properties that contribute more directly to the actual performance of lithium metal batteries are still insufficient. Research on the interfacial properties of polymer electrolytes with lithium metal has mainly focused on forming a robust solid electrolyte interphase (SEI) layer that is inorganic-rich (especially LiF-rich) and improving surface morphology by adopting early-stage liquid electrolyte research methods in the field, such as using an excessive amount of salt or introducing additives containing fluorine (F) groups.

[0004] Therefore, existing studies are limited to observing and partially improving the static state of lithium metal, and lack understanding and utilization of dynamic phenomena occurring at the actual interface.

SUMMARY

[0005] The present invention has been devised to solve the above-mentioned problems, and an object of the present invention is to provide a composition for preparing a polymer electrolyte, comprising a cationic monomer; a multifunctional monomer; a plastic crystal; and a lithium salt.

[0006] In addition, another object of the present invention is to provide a polymer electrolyte prepared using the above composition for preparing a polymer electrolyte.

[0007] In addition, another object of the present invention is to provide a lithium metal battery comprising the above polymer electrolyte.

[0008] Furthermore, another object of the present invention is to provide a device comprising the above lithium metal battery, wherein the device is selected from the group consisting of a communication device, a transportation device, and an energy storage device.

[0009] In addition, another object of the present invention is to provide a method for preparing a

polymer electrolyte, comprising:

[0010] (A) obtaining a composition for preparing a polymer electrolyte by mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt; and (B) preparing the polymer electrolyte by polymerizing the composition for preparing a polymer electrolyte.

[0011] The objects of the present invention are not limited to the purposes mentioned above, and other objects and advantages of the present invention that are not mentioned can be understood through the following description and will be more clearly understood through the embodiments of the present invention. In addition, it will be easily understood that the objects and advantages of the present invention can be achieved by the means and combinations thereof described in the specification.

[0012] One aspect of the present invention provides a composition for preparing a polymer electrolyte, comprising a cationic monomer; a multifunctional monomer; a plastic crystal; and a lithium salt.

[0013] The cationic monomer may comprise at least one selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium.

[0014] The cationic monomer may comprise a cationic functional group; and an anionic functional group.

[0015] The anionic functional group may be an imide compound functional group.

[0016] The multifunctional monomer may comprise at least one selected from the group consisting of trimethylolpropane propoxylate triacrylate (TPPTA), ethoxylated trimethylolpropane triacrylate (ETPTA), trimethylolpropane triacrylate (TMPTA), and poly(ethylene glycol) diacrylate (PEGDA).

[0017] The molar ratio of the cationic monomer to the multifunctional monomer may be from 70 to 90 : 30 to 10.

[0018] The plastic crystal may be at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile. The content of the plastic crystal may be from 58 to 83 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

[0019] The lithium salt may comprise at least one selected from the group consisting of lithium bis(trifluoromethanesulfonyl)imide (LiTFSI), lithium bis(pentafluoroethanesulfonyl)imide (LiBETI), and lithium bis(fluorosulfonyl)imide (LiFSI).

[0020] The content of the lithium salt may be from 35 to 65 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

[0021] The composition for preparing the polymer electrolyte may further comprise at least one additive selected from the group consisting of vinylene carbonate and fluoroethylene carbonate (FEC).

[0022] The content of the additive may be from 1 to 10 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

[0023] The composition for preparing the polymer electrolyte may further comprise an initiator.

[0024] Another aspect of the present invention provides a polymer electrolyte prepared using the composition for preparing the polymer electrolyte.

[0025] Another aspect of the present invention provides a lithium metal battery comprising the polymer electrolyte.

[0026] Another aspect of the present invention provides a device comprising the lithium metal battery, wherein the device is selected from the group consisting of a communication device, a

transportation device, and an energy storage device.

[0027] Another aspect of the present invention provides a method for preparing a polymer electrolyte, comprising:

[0028] (A) obtaining a composition for preparing a polymer electrolyte by mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt; and (B) preparing the polymer electrolyte by polymerizing the composition for preparing the polymer electrolyte.

[0029] The polymerization may be performed at a temperature of 58 to 95°C for 1 to 7 hours.

[0030] The means for solving the above problems do not enumerate all features of the present invention, and may be combined with certain embodiments described in the present specification. Various features of the present invention and the advantages and effects thereof can be understood in more detail with reference to the following detailed description.

[0031] The polymer electrolyte of the present invention exhibits excellent ion transport properties.

[0032] In addition to the above-described effects, specific effects of the present invention will be described together while explaining specific details for carrying out the invention below. Furthermore, the effects of the present invention are not limited to the effects mentioned above, and can be easily realized by the means and combinations thereof described in the specification

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] FIG. 1 is a schematic view illustrating the structure and dynamic response of a polymer electrolyte (WCCE, Control 2) according to one embodiment of the present invention and a polymer electrolyte (Control 1) in which a neutral polymer (matrix) is introduced.

[0034] FIG. 2 shows (a) a schematic diagram illustrating the molecular interactions in a polymer electrolyte (Control 1) in which a neutral polymer (matrix) is introduced and a polymer electrolyte (WCCE, Control 2) according to one embodiment of the present invention, and (b) FT-IR spectra, (c) ^{15}N NMR spectra, and (d) ^7Li NMR spectra of the polymer electrolytes prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[0035] FIG. 3 shows (a) the Tafel slope, (b) voltage profiles (current density = 0.1 mA cm^{-2} / capacity = 0.1 mA cm^{-2}), and (c) voltage profiles (increased from 0.1 mA cm^{-2} to 1.5 mA cm^{-2} at a rate of $0.1 \text{ mA cm}^{-2} \text{ h}^{-1}$) of lithium metal batteries ($\text{Li}||\text{Li}$ cells) prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention, and (d)–(f) scanning electron microscope (SEM) images of the lithium metal anodes in the lithium metal batteries prepared in (d) Comparative Example 1 (Control 1), (e) Example 2 (Control 2), and (f) Example 1 (WCCE).

[0036] FIG. 4 shows the Nyquist plot of $\text{SUS}||\text{SUS}$ cells prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[0037] FIG. 5 shows the current–time graphs (left) and Nyquist plots (right) under 10 mV polarization of lithium metal batteries ($\text{Li}||\text{Li}$ symmetric cells) prepared in (a, b) Comparative Example 1 (Control 1), (c, d) Example 2 (Control 2), and (e, f) Example 1 (WCCE) of the present invention.

[0038] FIG. 6 shows the Nyquist plots of lithium metal batteries prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0039] In the present specification, a singular expression includes a plural expression unless the context clearly indicates otherwise.

[0040] In the present specification, a numerical range indicated by the term "to" represents a

numerical range including the values stated before and after the term as the lower and upper limits, respectively. For example, when “a to b” is described in the specification, it can be understood as meaning a range from a to b, inclusive.

[0041] In the present specification, when a plurality of numerical values are disclosed as the lower and upper limits of a numerical range, the numerical range disclosed in the specification can be understood as any numerical range having any one of the plurality of lower limit values and any one of the plurality of upper limit values as the lower limit and upper limit, respectively. For example, when “not less than a” or “not less than b”; and “not more than c” or “not more than d” are described, it can be understood as meaning “not less than a and not more than c,” “not less than a and not more than d,” “not less than b and not more than c,” or “not less than b and not more than d.”

[0042] One aspect of the present invention provides a composition for preparing a polymer electrolyte, comprising a cationic monomer; a multifunctional monomer; a plastic crystal; and a lithium salt.

[0043] When applied as a polymer electrolyte, the composition for preparing a polymer electrolyte according to the present invention exhibits dominant weak attractive interactions between the metal ion (Li^+) and the solvent (or anion) due to the double coordination structure consisting of metal ion–solvent (or anion)–cationic polymer (polymerized from cationic monomer). Accordingly, since the metal ion has a primary coordination structure formed with the mobile phase solvent or anion, without directly interacting with the stationary phase cationic polymer matrix, the ion transport property in the bulk electrolyte is improved. In addition, due to the double coordination structure, the binding energy between the metal ion and the solvent (or anion) is reduced, thereby facilitating de-coordination of the metal ion at the electrolyte/electrode interface during battery charging, which reduces interfacial charge transfer resistance and suppresses lithium

dendrite growth.

[0044] The present invention is characterized in that a polymer polymerized from a cationic monomer is used as the matrix of the polymer electrolyte, which, unlike neutral monomers and neutral polymers, is capable of directly interacting with the plastic crystal. This interaction reduces the lithium ion coordination ability of the plastic crystal that coordinates lithium ions in the electrolyte, thereby improving the lithium ion de-coordination kinetics at the interface (regulation of static lithium ion coordination structure), increasing ionic conductivity, and reducing charge transfer resistance at the electrode surface.

[0045] The cationic monomer may comprise at least one selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium; preferably, may comprise imidazolium; more preferably, may comprise imidazolium in which a methyl group is introduced at the 3-position of the imidazolium ring; and most preferably, may comprise 1-allyl-3-methylimidazolium.

[0046] The cationic monomer may be a salt compound comprising a cationic functional group; and an anionic functional group. The salt compound may refer to an ionic compound in which the cation and the anion are electrostatically bound to each other to exhibit a neutral state.

[0047] According to one embodiment of the present invention, in the case of the cationic monomer, the presence of a counter anion is essential, and therefore, the cationic functional group may be present together with a counter anion.

[0048] The features described in the above-described embodiment may be combined with other embodiments unless explicitly described otherwise. Although the preferred embodiments of the present invention have been described in detail above, the scope of the present invention is not limited thereto, and various modifications and improvements made by those skilled in the art using

the basic concept of the present invention defined in the following claims also fall within the scope of the present invention.

[0049] The cationic functional group may be at least one functional group selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium; preferably, the cationic functional group may be an imidazolium functional group; more preferably, the functional group may be a functional group in which a methyl group is introduced at the 3-position of the imidazolium ring; and most preferably, the functional group may be a 1-allyl-3-methylimidazolium functional group.

[0050] In particular, it is most preferable when the cationic monomer comprises a compound of 1-allyl-3-methylimidazolium or a functional group thereof, as the chemical stability can be significantly increased.

[0051] The anionic functional group may be an imide compound functional group, and more preferably, may be a bis(trifluoromethanesulfonyl)imide functional group. In particular, bis(trifluoromethanesulfonyl)imide is more preferably used as an anionic functional group, since it facilitates salt dissociation and forms F-containing decomposition products at the electrode, which can increase reversibility.

[0052] According to a preferred embodiment of the present invention, the cationic monomer may be 1-allyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (AMIM-TFSI). In particular, AMIM-TFSI is most preferable, since unlike other cationic monomers, it can reduce charge transfer resistance by at least 10%.

[0053] The multifunctional monomer may be a compound having a polymerizable functional group capable of bonding with the cationic monomer, and preferably, may be a multifunctional monomer having two or more of the polymerizable functional groups.

[0054] The polymerizable functional group may be an acryl group.

[0055] The polymerizable functional group may react and bond with the cationic functional group of the cationic monomer to interconnect the cationic monomers and form a polymer.

[0056] The multifunctional monomer may comprise at least one selected from the group consisting of trimethylolpropane propoxylate triacrylate (TPPTA), ethoxylated trimethylolpropane triacrylate (ETPTA), trimethylolpropane triacrylate (TMPTA), and poly(ethylene glycol) diacrylate (PEGDA); preferably, may be a polyol ester-based acrylate compound; and more preferably, may be trimethylolpropane propoxylate triacrylate (TPPTA).

[0057] The cationic monomer and the multifunctional monomer are each present in the composition, but they are polymerized to form a polymer.

[0058] The molar ratio of the cationic monomer to the multifunctional monomer may be from 70 to 90 : 30 to 10, preferably from 73 to 87 : 27 to 13, more preferably from 75 to 85 : 25 to 15, and most preferably from 68 to 82 : 32 to 18.

[0059] When the cationic monomer and the multifunctional monomer are used outside the above molar ratio, the mechanical properties of the resulting polymer electrolyte may deteriorate, and a large number of defects may occur on the surface.

[0060] The plastic crystal increases the dielectric constant of the polymer electrolyte and weakens the bonding between the cationic polymer matrix, which is derived from the cationic monomer, and the metal ion.

[0061] The plastic crystal may be at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile.

[0062] The nitrile-based compound may be a nitrile-based compound having 2 to 5 carbon atoms, excluding the nitrile group within the molecule. Nitrile-based compounds having more than 5 carbon atoms are not suitable for use in electrolytes due to their solid phase or high viscosity.

[0063] The content of the plastic crystal may be from 58 to 83 parts by weight, preferably from 60 to 80 parts by weight, more preferably from 62 to 77 parts by weight, and most preferably from 65 to 75 parts by weight, based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer (thermosetting composition).

[0064] When the plastic crystal is used in an amount smaller than the above range based on 100 parts by weight of the thermosetting composition, the ionic conductivity may significantly decrease, and lithium dendrites may be generated even without prolonged cycling. On the other hand, when used in an excessive amount, the crosslinking density of the polymer electrolyte may decrease, and it may fail to exhibit solid-state properties.

[0065] In addition, the composition for preparing the polymer electrolyte of the present invention is characterized in that a lithium salt is used together with the plastic crystal, and the plastic crystal, in the presence of the lithium salt, becomes liquid, thereby making the polymer electrolyte prepared using the same into a gel electrolyte.

[0066] The lithium salt may comprise at least one selected from the group consisting of lithium bis(trifluoromethanesulfonyl)imide (LiTFSI), lithium bis(pentafluoroethanesulfonyl)imide (LiBETI), and lithium bis(fluorosulfonyl)imide (LiFSI); preferably, the lithium salt may be lithium bis(fluorosulfonyl)imide (LiFSI, $\text{LiF}_2\text{NO}_4\text{S}_2$).

[0067] The content of the lithium salt may be from 35 to 65 parts by weight, preferably from 37 to 63 parts by weight, more preferably from 40 to 60 parts by weight, and most preferably from 45 to 55 parts by weight, based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer (thermosetting composition).

[0068] When the lithium salt is used in an amount smaller than the above range based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer (thermosetting composition), dynamic lithium ion coordination structure regulation may not be

achieved, and the effect of reducing interfacial charge transfer resistance may fall short of expectations. On the other hand, when used in an excessive amount, the lithium ion conductivity of the polymer electrolyte may be significantly decreased.

[0069] In particular, the composition for preparing a polymer electrolyte of the present invention can increase the content of the lithium salt up to the solubility limit to increase the proportion of anions included in the primary coordination structure within the polymer electrolyte. As a result, the Li^+ coordination energy is reduced, and during charging, the lithium metal anode becomes negatively polarized, causing repulsion of anions from the surface. This further reduces the Li^+ coordination energy at the electrolyte/anode interface, thereby facilitating Li^+ de-coordination during charging and further reducing interfacial charge transfer resistance, which suppresses lithium dendrite growth. In addition, it promotes the decomposition of anions at the lithium metal anode, forming a LiF-rich SEI to stabilize the interface and further suppress lithium dendrite growth.

[0070] According to a preferred embodiment of the present invention, the cationic monomer is 1-allyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide (AMIM-TFSI), the multifunctional monomer is trimethylolpropane propoxylate triacrylate (TPPTA), and the plastic crystal may be at least one selected from the group consisting of succinonitrile (butanedinitrile, $\text{C}_2\text{H}_4(\text{CN})_2$), glutaronitrile, and adiponitrile.

[0071] When the composition for preparing a polymer electrolyte of the present invention satisfies all the components according to the preferred embodiment, it was confirmed that it is more preferable in that, even after 250 charge-discharge cycles using a lithium metal battery prepared with the polymer electrolyte produced therefrom, no defects occurred on the surface of the polymer electrolyte. However, when any one of the components of the preferred embodiment was not satisfied, defects were generated on the surface of the polymer electrolyte after 250 charge-

discharge cycles.

[0072] According to another preferred embodiment of the present invention, the molar ratio of the cationic monomer to the multifunctional monomer is 68 to 82 : 32 to 18, the content of the plastic crystal is from 65 to 75 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer, and the lithium salt may be from 45 to 55 parts by weight.

[0073] When the composition of the composition for preparing a polymer electrolyte of the present invention satisfies all the numerical ranges of the above-described another preferred embodiment, it was confirmed that the mechanical properties and surface uniformity of the polymer electrolyte, prepared using the composition and applied to a lithium metal battery, were maintained the same as the initial state even after 250 charge-discharge cycles. However, when any one of the compositional ranges of the another preferred embodiment was not satisfied, the surface uniformity was degraded compared to the initial state after 250 charge-discharge cycles, and the mechanical properties decreased by at least 7%.

[0074] The composition for preparing the polymer electrolyte may further comprise an additive.

[0075] The additive serves to stabilize the surface of the lithium metal, and specifically, may be at least one selected from the group consisting of vinylene carbonate and fluoroethylene carbonate (FEC); preferably, the additive may be fluoroethylene carbonate (FEC).

[0076] The content of the additive may be from 1 to 10 parts by weight, preferably from 2 to 7 parts by weight, based on 100 parts by weight of the thermosetting composition.

[0077] When the additive is used in an amount smaller than the above range based on 100 parts by weight of the thermosetting composition, stabilization of the lithium metal anode may be difficult. On the other hand, when used in an excessive amount, the additive may decompose itself excessively, thereby lowering the Coulombic efficiency.

[0078] The composition for preparing the polymer electrolyte may further comprise an initiator.

[0079] The initiator induces a polymerization reaction of the cationic monomer and the multifunctional monomer to form a polymer.

[0080] The initiator is not particularly limited as long as it is a substance that induces the polymerization reaction of the cationic monomer and the multifunctional monomer, and in one embodiment, it may be 2,2'-azobis(2-methylpropionitrile) (AIBN).

[0081] The content of the initiator may be from 0.05 to 10 parts by weight, preferably from 0.1 to 7 parts by weight, based on 100 parts by weight of the thermosetting composition.

[0082] When the initiator is used in an amount smaller than the above range based on 100 parts by weight of the thermosetting composition, the polymer may not be sufficiently formed. On the other hand, when used in an excessive amount, it may cause side reactions in the battery and deteriorate battery performance.

[0083] Another aspect of the present invention provides a polymer electrolyte prepared using the composition for preparing the polymer electrolyte.

[0084] The polymer electrolyte may be prepared by polymerizing the composition for preparing the polymer electrolyte, and the polymerization may be thermal polymerization or photopolymerization.

[0085] The polymer electrolyte may comprise a cationic polymer matrix polymerized from a thermosetting composition comprising the cationic monomer and the multifunctional monomer.

[0086] The room temperature ionic conductivity of the polymer electrolyte may be from 1.2×10^{-3} to 2.1×10^{-3} S/cm, and the room temperature charge transfer resistance may be from 30 to 50 Ω .

[0087] FIG. 1 is a schematic diagram illustrating the structure and dynamic response of a polymer electrolyte (WCCE, Control 2) according to one embodiment of the present invention and a polymer electrolyte (Control 1) in which a neutral polymer (matrix) is introduced.

[0088] As shown in FIG. 1, the polymer electrolyte (Control 1) in which a neutral polymer (matrix) is introduced exhibits strong interaction between the metal (lithium) and the neutral polymer, making ion transport difficult and limiting metal plating/stripping. Even when a plastic crystal is further added, the plastic crystal also strongly interacts with the metal, thereby further restricting the metal plating/stripping.

[0089] In addition, the polymer electrolyte (WCCE, Control 2) according to one embodiment of the present invention allows regulation of a static coordination structure due to the double coordination structure of metal ion (Li^+)–solvent (or anion)–cationic polymer. As a result, Li^+ does not directly interact with the stationary phase cationic polymer matrix but instead forms a primary coordination structure with the mobile phase solvent or anion, thereby improving ion transport properties in the bulk electrolyte. Furthermore, the binding energy between Li^+ and the solvent (or anion) is reduced, facilitating Li^+ de-coordination at the electrolyte/anode interface during charging.

[0090] In addition, the WCCE has a higher concentration of lithium salt than the polymer electrolyte (Control 2) in which the cationic polymer is introduced. By increasing the concentration of the lithium salt, the proportion of anions in the primary coordination structure is further increased, thereby achieving additional reduction in binding energy through utilization of anion repulsion at the lithium metal anode interface during charging, and accomplishing regulation of both static and dynamic coordination structures.

[0091] In addition, the present invention provides a lithium metal battery comprising the polymer electrolyte.

[0092] Furthermore, the present invention provides a device comprising the lithium metal battery, wherein the device is selected from the group consisting of a communication device, a transportation device, and an energy storage device.

[0093] Another aspect of the present invention provides a method for preparing a polymer electrolyte, comprising:

[0094] (A) obtaining a composition for preparing a polymer electrolyte by mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt; and (B) preparing the polymer electrolyte by polymerizing the composition for preparing the polymer electrolyte.

[0095] (A) obtaining a composition for preparing a polymer electrolyte by mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt

[0096] The step (A) is a step of obtaining a composition for preparing a polymer electrolyte by mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt.

[0097] The cationic monomer may comprise at least one selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium; preferably, may comprise imidazolium; more preferably, may comprise imidazolium in which a methyl group is introduced at the 3-position of the imidazolium ring; and most preferably, may comprise 1-allyl-3-methylimidazolium.

[0098] The cationic monomer may be a salt compound comprising a cationic functional group; and an anionic functional group.

[0099] The cationic functional group may be at least one functional group selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium; preferably, may be an imidazolium functional group; more preferably, may be a functional group in which a methyl group is introduced at the 3-position of the imidazolium ring; and most preferably, may be a 1-allyl-3-methylimidazolium functional group.

[00100] The anionic functional group may be an imide compound functional group, and

more preferably, may be a bis(trifluoromethanesulfonyl)imide functional group.

[00101] According to a preferred embodiment of the present invention, the cationic monomer may be 1-allyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide (AMIM-TFSI).

[00102] The multifunctional monomer may be a compound having a polymerizable functional group capable of bonding with the cationic monomer, and preferably, may be a multifunctional monomer having two or more of the polymerizable functional groups.

[00103] The polymerizable functional group may be an acryl group.

[00104] The polymerizable functional group may react and bond with the cationic functional group of the cationic monomer to interconnect the cationic monomers and form a polymer.

[00105] The multifunctional monomer may be an acrylate compound, preferably a polyol ester-based acrylate compound, and more preferably, trimethylolpropane propoxylate triacrylate (TPPTA).

[00106] The cationic monomer and the multifunctional monomer are each present in the composition, but they are polymerized to form a polymer.

[00107] The molar ratio of the cationic monomer to the multifunctional monomer may be from 70 to 90 : 30 to 10, preferably from 73 to 87 : 27 to 13, more preferably from 75 to 85 : 25 to 15, and most preferably from 68 to 82 : 32 to 18.

[00108] The plastic crystal may be at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile.

[00109] The content of the plastic crystal may be from 58 to 83 parts by weight, preferably from 60 to 80 parts by weight, more preferably from 62 to 77 parts by weight, and most preferably from 65 to 75 parts by weight, based on 100 parts by weight of the total of the cationic monomer

and the multifunctional monomer (thermosetting composition).

[00110] The lithium salt may comprise at least one selected from the group consisting of lithium bis(trifluoromethanesulfonyl)imide (LiTFSI), lithium bis(pentafluoroethanesulfonyl)imide (LiBETI), and lithium bis(fluorosulfonyl)imide (LiFSI); preferably, the lithium salt may be lithium bis(fluorosulfonyl)imide (LiFSI, $\text{LiF}_2\text{NO}_4\text{S}_2$).

[00111] The content of the lithium salt may be from 35 to 65 parts by weight, preferably from 37 to 63 parts by weight, more preferably from 40 to 60 parts by weight, and most preferably from 45 to 55 parts by weight, based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer (thermosetting composition).

[00112] The composition for preparing the polymer electrolyte may further comprise an additive.

[00113] The additive may be at least one selected from the group consisting of vinylene carbonate and fluoroethylene carbonate (FEC); preferably, the additive may be fluoroethylene carbonate (FEC).

[00114] The content of the additive may be from 1 to 10 parts by weight, preferably from 2 to 7 parts by weight, based on 100 parts by weight of the thermosetting composition.

[00115] The composition for preparing the polymer electrolyte may further comprise an initiator.

[00116] The initiator may be 2,2'-azobis(2-methylpropionitrile) (AIBN). The content of the initiator may be from 0.05 to 10 parts by weight, preferably from 0.1 to 7 parts by weight, based on 100 parts by weight of the thermosetting composition.

[00117] (B) preparing the polymer electrolyte by polymerizing the composition for preparing the polymer electrolyte

[00118] The step (B) is a step of preparing a polymer electrolyte by polymerizing the composition for preparing the polymer electrolyte.

[00119] In the step (B), a polymer may be polymerized from a thermosetting composition comprising the cationic monomer and the multifunctional monomer.

[00120] The polymerization may be thermal polymerization or photopolymerization.

[00121] The thermal polymerization may be performed at a temperature of 58 to 95°C for 1 to 7 hours, preferably at 60 to 90°C for 2 to 6 hours, more preferably at 63 to 85°C for 2.3 to 5 hours, and most preferably at 65 to 78°C for 2.5 to 4 hours.

[00122] When either the temperature or time of the thermal polymerization is below the lower limit, the mechanical properties of the polymer electrolyte may deteriorate, and conversely, when either exceeds the upper limit, a large amount of by-products may be generated. When either the temperature or time of the thermal polymerization is below the lower limit, the mechanical properties of the polymer electrolyte may deteriorate, and conversely, when either exceeds the upper limit, a large amount of by-products may be generated.

[00123] Although not explicitly described in the following examples and comparative examples, after preparing a polymer electrolyte by varying the following conditions in the method for preparing the polymer electrolyte of the present invention, a lithium metal battery was prepared using the polymer electrolyte, and subjected to 800 charge-discharge cycles by conventional methods.

[00124] As a result, when all the following conditions were satisfied, lithium dendrites were not formed at all even after 250 charge-discharge cycles, and the ionic conductivity and interfacial charge transfer resistance characteristics were maintained at the same level as initially, confirming that long-term stability was particularly excellent.

[00125] However, when any one of the following conditions is not satisfied, lithium

dendrites were observed starting from up to 250 charge-discharge cycles, or the ionic conductivity and interfacial charge transfer resistance characteristics decreased by 8% or more compared to the initial state, resulting in somewhat reduced long-term stability.

[00126] (1) The cationic monomer is 1-allyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide (AMIM-TFSI);

[00127] (2) The multifunctional monomer is trimethylolpropane propoxylate triacrylate (TPPTA);

[00128] (3) The molar ratio of the cationic monomer to the multifunctional monomer is from 68 to 82 : 32 to 18;

[00129] (4) The plastic crystal is at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile;

[00130] (5) The content of the plastic crystal is from 65 to 75 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer;

[00131] (6) The content of the lithium salt is from 45 to 55 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer;

[00132] (7) The composition for preparing the polymer electrolyte further comprises fluoroethylene carbonate (FEC);

[00133] (8) The content of fluoroethylene carbonate (FEC) is from 2 to 7 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer; and

[00134] (9) The polymerization may be performed at 65 to 78°C for 2.5 to 4 hours.

[00135] The present invention will be described in more detail below through examples and the like; however, the scope and content of the present invention should not be interpreted as being limited or restricted by the examples and the like described below.

[00136] Example 1. Weakly coordinating cationic polymer electrolyte (WCCE) and a lithium metal battery comprising the same

[00137] A precursor solution was prepared by mixing a cationic monomer (1-allyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (AMIM-TFSI)), a crosslinker (trimethylolpropane propoxylate triacrylate (TPPTA)), a plastic crystal (succinonitrile, SN), a lithium salt (lithium bis(fluorosulfonyl)imide (LiFSI)), an additive (fluoroethylene carbonate (FEC)), and an initiator (2,2'-azobis(2-methylpropionitrile) (AIBN)) at a weight ratio of 100 : 40 : 100 : 72 : 6 : 0.5.

[00138] At this time, the molar ratio of the cationic monomer to the crosslinker was 80 : 20.

[00139] Then, after injecting the precursor solution into the cell and assembling it, the lithium metal battery including the polymer electrolyte formed by an in situ method was prepared by heating at 70°C for 3 hours.

[00140] Example 2. Control 2

[00141] A precursor solution was prepared by mixing a cationic monomer (1-allyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (AMIM-TFSI)), a crosslinker (trimethylolpropane propoxylate triacrylate (TPPTA)), a plastic crystal (succinonitrile, SN), a lithium salt (lithium bis(fluorosulfonyl)imide (LiFSI)), an additive (fluoroethylene carbonate (FEC)), and an initiator (2,2'-azobis(2-methylpropionitrile) (AIBN)) at a weight ratio of 100 : 40 : 100 : 29 : 5.5 : 0.5. At this time, the molar ratio of the cationic monomer to the crosslinker was 80 : 20.

[00142] Then, after injecting the precursor solution into the cell and assembling it, the

lithium metal battery including the polymer electrolyte formed by an in situ method was prepared by heating at 70°C for 3 hours.

[00143] Comparative Example 1. Control 1

[00144] A precursor solution was prepared by mixing a neutral monomer (trimethylolpropane 1-allylimidazole), a crosslinker (trimethylolpropane propoxylate triacrylate (TPPTA)), a plastic crystal (succinonitrile, SN), a lithium salt (lithium bis(fluorosulfonyl)imide (LiFSI)), an additive (fluoroethylene carbonate (FEC)), and an initiator (2,2'-azobis(2-methylpropionitrile) (AIBN)) at a weight ratio of 100 : 149 : 370 : 108 : 15 : 2. At this time, the molar ratio of the neutral monomer to the crosslinker was 80 : 20.

[00145] Then, after injecting the precursor solution into the cell and assembling it, the lithium metal battery including the polymer electrolyte formed by an in situ method was prepared by heating at 70°C for 3 hours.

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[00146] Experimental Example 1. Coordination Energy Analysis

[00147] FIG. 2 shows (a) a schematic diagram illustrating the interactions of molecules within a polymer electrolyte (Control 1) in which a neutral polymer (matrix) is introduced and a polymer electrolyte (WCCE, Control 2) according to one embodiment of the present invention, and (b) FT-IR spectra, (c) ¹⁵N NMR spectra, and (d) ⁷Li NMR spectra of polymer electrolytes prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[00148] As shown in (b) of FIG. 2, in Example 1 (WCCE) and Example 2 (Control 2), which include the cationic monomer, the nitrile (in SN)-Li⁺ interaction is weakened, reducing the degree to which nitrile (in SN) donates electron density to Li⁺. As a result, the C≡N bond strength

(in SN) increased, and the FT-IR peak corresponding to coordinating SN due to mutual coordination was detected at a higher wavenumber (2280 cm^{-1} vs. 2276 cm^{-1}) compared to Comparative Example 1 (Control 1).

[00149] As shown in (c) of FIG. 2, the lithium ion coordination is statically regulated, resulting in a decrease in the degree to which nitrile donates electron density to Li^+ . This causes localization of electrons in the nitrile group, and it was confirmed that the peak of the nitrile group was shielded in the ^{15}N NMR spectrum.

[00150] As shown in (d) of FIG. 2, in Example 1 (WCCE) and Example 2 (Control 2), which include the cationic monomer, the presence of mutual coordination decreases the coordinating ability of the ligand, increasing the proportion of anions within the Li^+ coordination sheath. As a result, lithium ion coordination is statically regulated, and an upshift of the Li^+ peak was observed in the ^7Li NMR spectrum.

[00151] In addition, compared to Example 2 (Control 2), Example 1 (WCCE) showed an upshift of the Li^+ peak due to the effect of mutual coordination and an increased ion pairing effect resulting from the introduction of a high concentration lithium salt. That is, as shown in FIG. 2, with the introduction of the cationic monomer, the interaction between lithium ions and the plastic crystal is weakened, resulting in an increase in the bond strength of the nitrile bond in the plastic crystal (succinonitrile).

[00152] Experimental Example 2. Electrochemical Performance Evaluation

[00153] The electrochemical performance of lithium metal batteries prepared in Example 1 and Comparative Examples 1 to 2 was evaluated, and the results are shown in (a) to (c) of FIG. 3.

[00154] FIG. 3 shows (a) the Tafel slopes, (b) the voltage profiles (current density = 0.1

mA/cm², capacity = 0.1 mA/cm²), and (c) the voltage profiles (current density increased from 0.1 mA/cm² to 1.5 mA/cm² at a rate of 0.1 mA/cm²·h⁻¹) of lithium metal batteries (Li||Li cells) prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[00155] As shown in (a) of FIG. 3, in Examples 1 and 2, lithium ion de-coordination is promoted, improving the kinetics of the electrochemical reaction, resulting in higher exchange current density compared to the comparative example.

[00156] As shown in (b) of FIG. 3, compared to the comparative example, the examples exhibited lower overvoltage and superior lifetime characteristics due to improved electrochemical reaction kinetics. In particular, among the examples, Example 1 exhibited an overvoltage of 15 mV or less for more than 1000 hours at a current density of 0.1 mA/cm² and a capacity of 0.1 mA/cm².

[00157] As shown in (c) of FIG. 3, the examples exhibit a higher limiting current density based on improved electrochemical reaction kinetics compared to the comparative examples.

[00158] Experimental Example 3. Surface Evaluation

[00159] In order to demonstrate the Li plating/stripping stability of lithium metal batteries prepared in Example 1 and Comparative Examples 1 to 2, the surface morphology of the lithium metal anode after 50 cycles at a current density of 0.1 mA/cm² and a capacity of 0.1 mAh/cm² was analyzed by scanning electron microscopy (SEM), and the results are shown in (d) to (f) of FIG. 3.

[00160] FIG. 3 shows scanning electron microscope (SEM) images of lithium metal anodes in lithium metal batteries prepared in (d) Comparative Example 1 (Control 1), (e) Example 2 (Control 2), and (f) Example 1 (WCCE) of the present invention.

[00161] As shown in (d) to (f) of FIG. 3, the lithium metal anode of Comparative Example 1 exhibited dendrite formation with a porous surface, whereas Example 2, in which the coordination structure was partially regulated, formed a denser morphology with reduced dendrite growth. Example 1, in which all strategies capable of regulating the coordination structure were applied, induced the formation of the densest and dendrite-free uniform lithium metal surface morphology. This is because the low de-coordination energy barrier induces uniform lithium metal deposition, which is advantageous for forming a dense lithium metal surface with suppressed dendrite growth.

[00162] Experimental Example 4. Charge Transfer Characteristic Evaluation

[00163] The room temperature ionic conductivity of SUS||SUS cells prepared in Example 1 and Comparative Examples 1 to 2 was measured, and the results are shown in FIG. 4 and Table 1 below. FIG. 4 shows Nyquist plots of SUS||SUS cells prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[00164] The room temperature cationic yield (and lithium ion conductivity) of lithium metal batteries prepared in Example 1 and Comparative Examples 1 to 2 was measured, and the results are shown in FIG. 5 and Tables 1 to 2 below.

[00165] FIG. 5 shows current-time graphs (left) and Nyquist plots (right) under 10 mV polarization of lithium metal batteries (Li||Li symmetric cells) prepared in (a, b) Comparative Example 1 (Control 1), (c, d) Example 2 (Control 2), and (e, f) Example 1 (WCCE) of the present invention.

[00166] [Table 1]

	Control 1	Control 2	WCCE
t_{Li^+}	0.55	0.57	0.88
σ (mS cm ⁻¹)	1.56	2.46	1.73
σ_{Li^+} (mS cm ⁻¹)	0.86	1.40	1.52

[00167]

[00168] [Table 2]

	Applied voltage	I_0	I_s	R_0	R_s	t_{Li^+}
	(mV)	(μ A)	(μ A)	(Ω)	(Ω)	
Control 1	10	19.16	16.00	406.2	415.3	0.55
Control 2	10	56.69	51.54	151.20	150.00	0.57
WCCE	10	45.33	42.45	70.08	65.60	0.88

[00169]

[00170] As shown in FIGS. 4 and 5 and Tables 1 to 2, lithium ion de-coordination was promoted in Example 1 (WCCE) and Example 2 (Control 2), resulting in improved lithium ion conductivity compared to Comparative Example 1 (Control 1).

[00171] Room Temperature Charge Transfer Resistance

[00172] The room temperature charge transfer resistance of lithium metal batteries prepared in Example 1 and Comparative Examples 1 to 2 was measured, and the results are shown in FIG. 6 and Table 3 below.

[00173] FIG. 6 shows Nyquist plots of lithium metal batteries prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[00174] [Table 3]

	Control 1	Control 2	WCCE
$R_{ct} (\Omega \text{ cm}^2)$	589	221	126

[00175]

[00176] As shown in FIG. 6 and Table 3, lithium ion de-coordination is promoted in lithium metal batteries prepared in the examples compared to the comparative example, resulting in reduced charge transfer resistance at the lithium metal anode surface. Among them, it can be seen that the charge transfer resistance reduction effect of Example 1 is superior.

[00177] Although the embodiments of the present invention have been described above, those skilled in the art will appreciate that various modifications and changes can be made to the present invention without departing from the spirit of the invention as defined in the claims, including addition, modification, deletion, or supplementation of components, and such modifications and changes are also encompassed within the scope of the present invention.

WHAT IS CLAIMED IS:

1. A composition for preparing a polymer electrolyte, comprising:
a cationic monomer;
a multifunctional monomer;
a plastic crystal; and
a lithium salt.
2. The composition for preparing a polymer electrolyte according to claim 1, wherein the cationic monomer comprises at least one selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium.
3. The composition for preparing a polymer electrolyte according to claim 1, wherein the cationic monomer comprises a cationic functional group; and an anionic functional group.
4. The composition for preparing a polymer electrolyte according to claim 3, wherein the anionic functional group is an imide compound functional group.
5. The composition for preparing a polymer electrolyte according to claim 1, wherein the multifunctional monomer comprises at least one selected from the group consisting of

trimethylolpropane propoxylate triacrylate (TPPTA), ethoxylated trimethylolpropane triacrylate (ETPTA), trimethylolpropane triacrylate (TMPTA), and poly(ethylene glycol) diacrylate (PEGDA).

6. The composition for preparing a polymer electrolyte according to claim 1, wherein the molar ratio of the cationic monomer to the multifunctional monomer is from 70 to 90 : 30 to 10.

7. The composition for preparing a polymer electrolyte according to claim 1, wherein the plastic crystal is at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile.

8. The composition for preparing a polymer electrolyte according to claim 1, wherein the content of the plastic crystal is from 58 to 83 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

9. The composition for preparing a polymer electrolyte according to claim 1, wherein the lithium salt comprises at least one selected from the group consisting of lithium bis(trifluoromethanesulfonyl)imide (LiTFSI), lithium bis(pentafluoroethanesulfonyl)imide (LiBETI), and lithium bis(fluorosulfonyl)imide (LiFSI).

10. The composition for preparing a polymer electrolyte according to claim 1, wherein the content of the lithium salt is from 35 to 65 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

11. The composition for preparing a polymer electrolyte according to claim 1, further comprising at least one additive selected from the group consisting of vinylene carbonate and fluoroethylene carbonate (FEC).

12. The composition for preparing a polymer electrolyte according to claim 11, wherein the content of the additive is from 1 to 10 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

13. The composition for preparing a polymer electrolyte according to claim 1, further comprising an initiator.

14. A polymer electrolyte prepared using the composition for preparing a polymer electrolyte according to claim 1.

15. A lithium metal battery comprising the polymer electrolyte according to claim 14.

16. An apparatus comprising the lithium metal battery according to claim 15, wherein the apparatus is any one selected from the group consisting of a communication device, a transportation device, and an energy storage device.

17. A method for preparing a polymer electrolyte, comprising:

(A) mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt to obtain a composition for preparing a polymer electrolyte; and (B) polymerizing the

composition for preparing the polymer electrolyte to prepare the polymer electrolyte.

18. The method for preparing a polymer electrolyte according to claim 17, wherein the polymerization is performed at 58 to 95°C for 1 to 7 hours.

19. The method for preparing a polymer electrolyte according to claim 17, wherein:
the cationic monomer is 1-allyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (AMIM-TFSI);

the multifunctional monomer is trimethylolpropane propoxylate triacrylate (TPPTA);

the molar ratio of the cationic monomer to the multifunctional monomer is from 68 to 82 : 32 to 18;

the plastic crystal is at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile;

the content of the plastic crystal is from 65 to 75 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer;

the content of the lithium salt is from 45 to 55 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer;

the composition for preparing the polymer electrolyte further comprises fluoroethylene carbonate (FEC), and the content of fluoroethylene carbonate (FEC) is from 2 to 7 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer;
and

the polymerization is performed at 65 to 78°C for 2.5 to 4 hours.

ABSTRACT

The present invention relates to a cationic polymer electrolyte and a method for preparing the same, wherein the polymer electrolyte of the present invention exhibits excellent ion transport properties.

FIG. 1

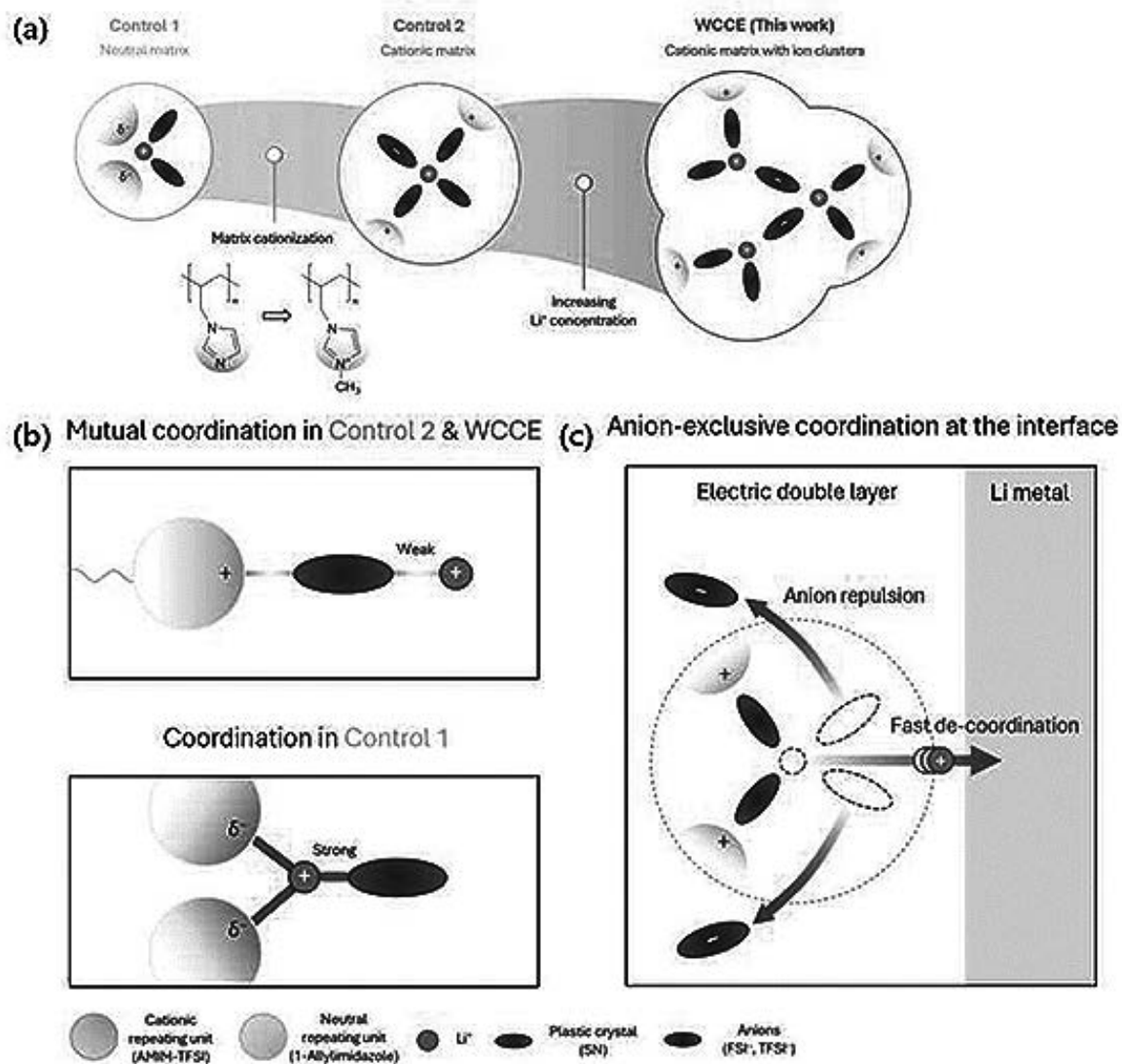


FIG. 2

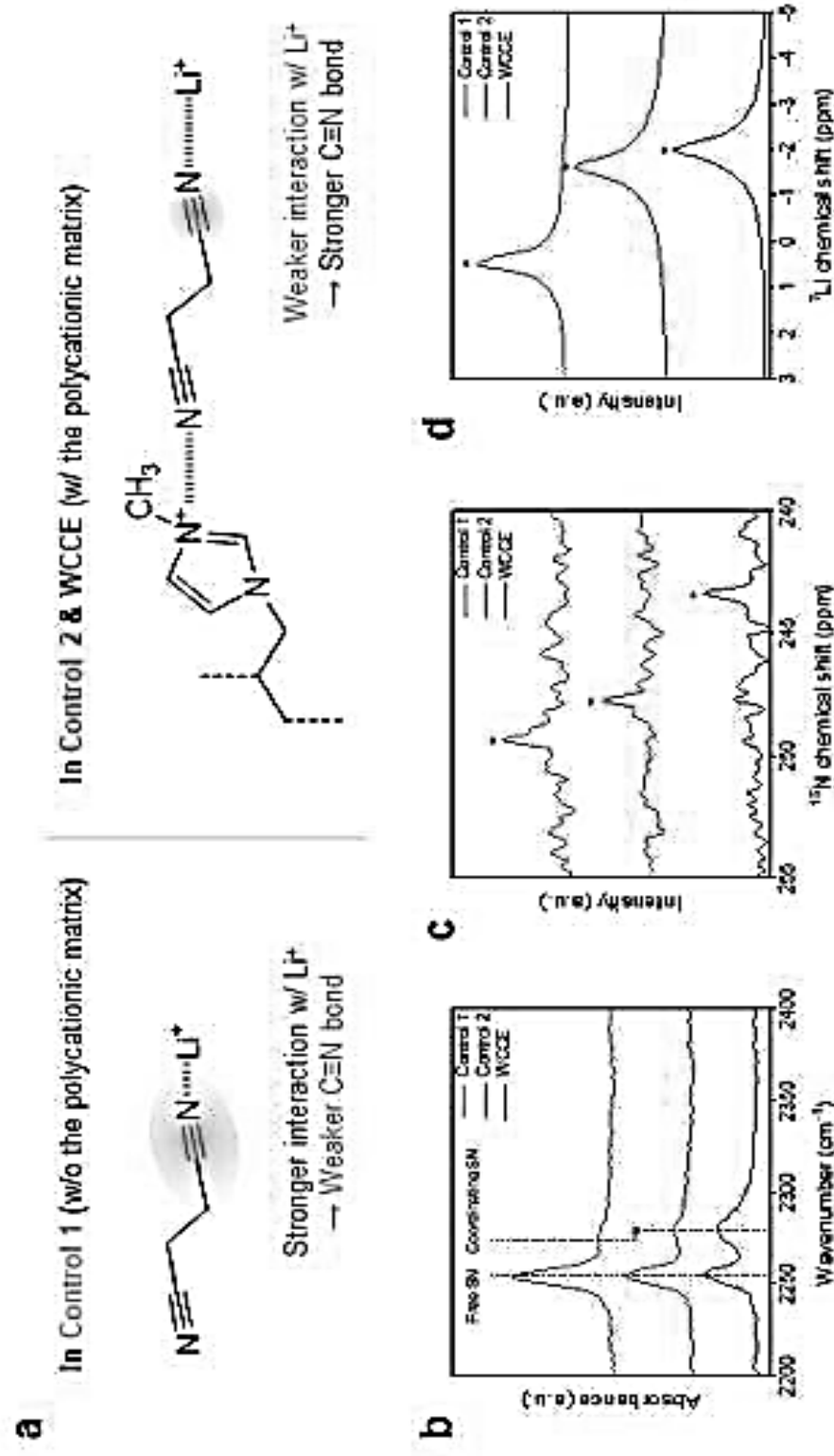


FIG. 3

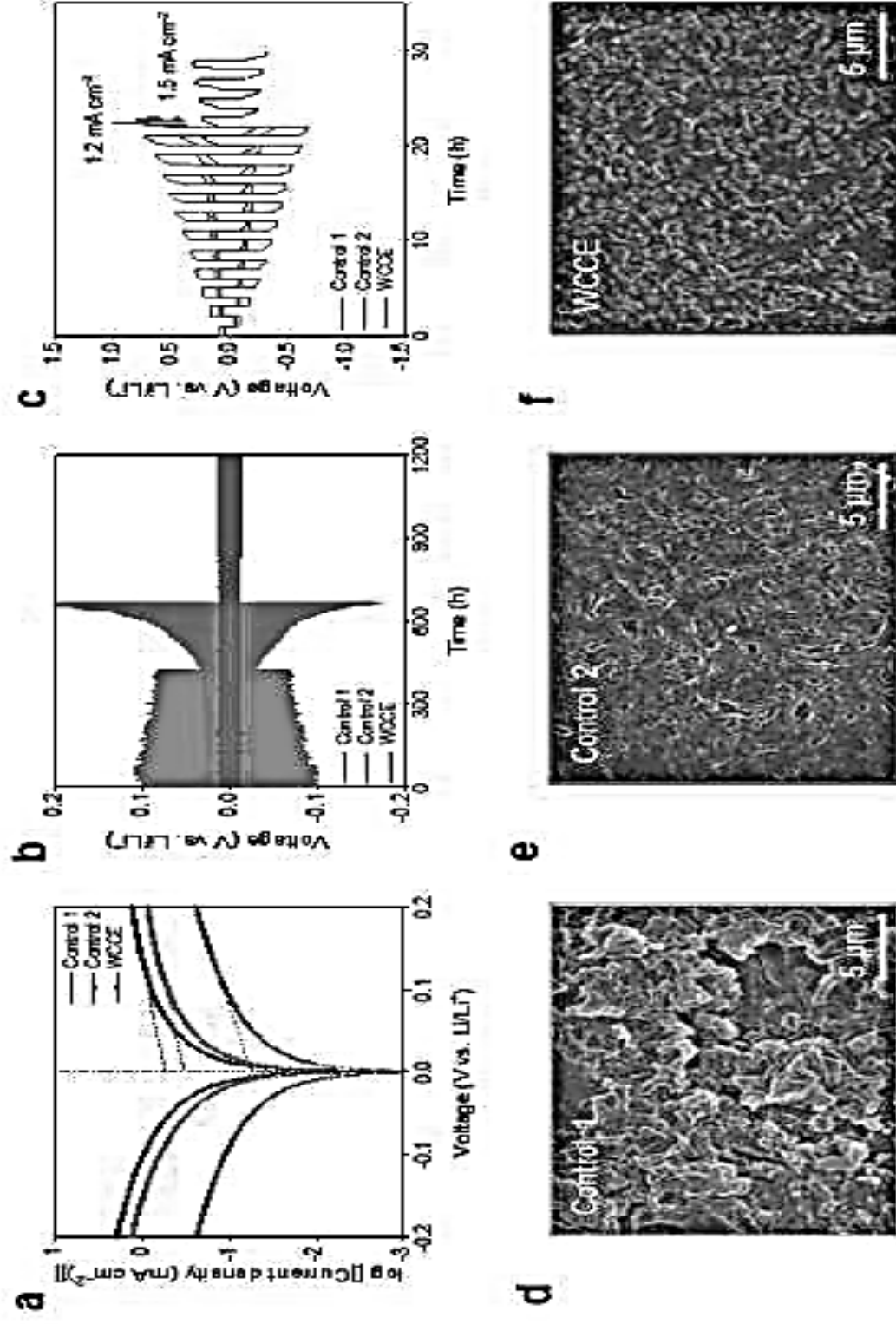


FIG. 4

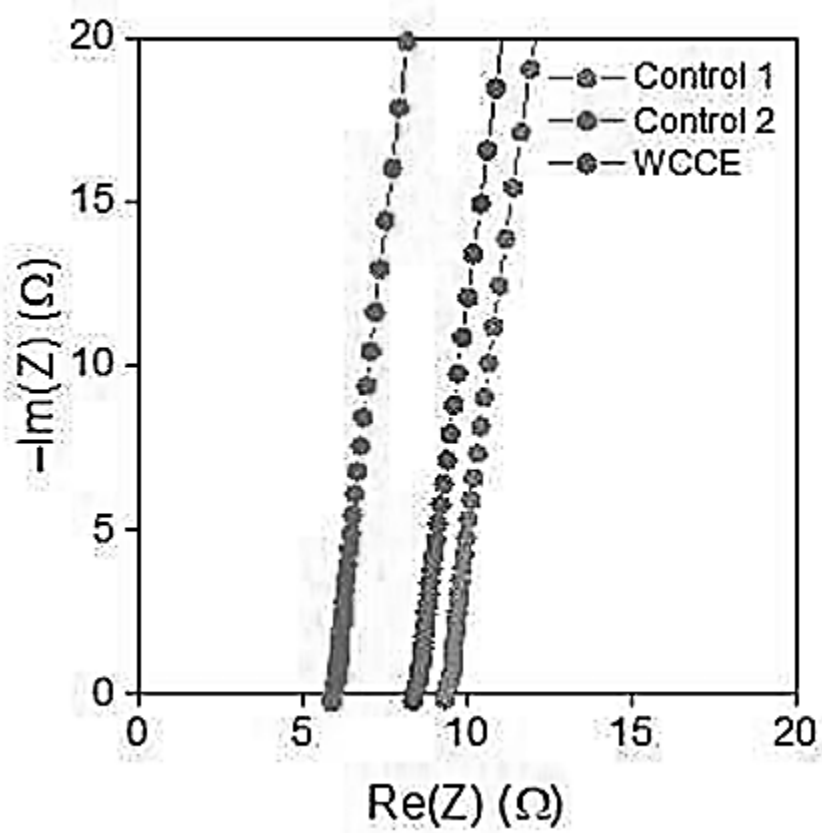


FIG. 5

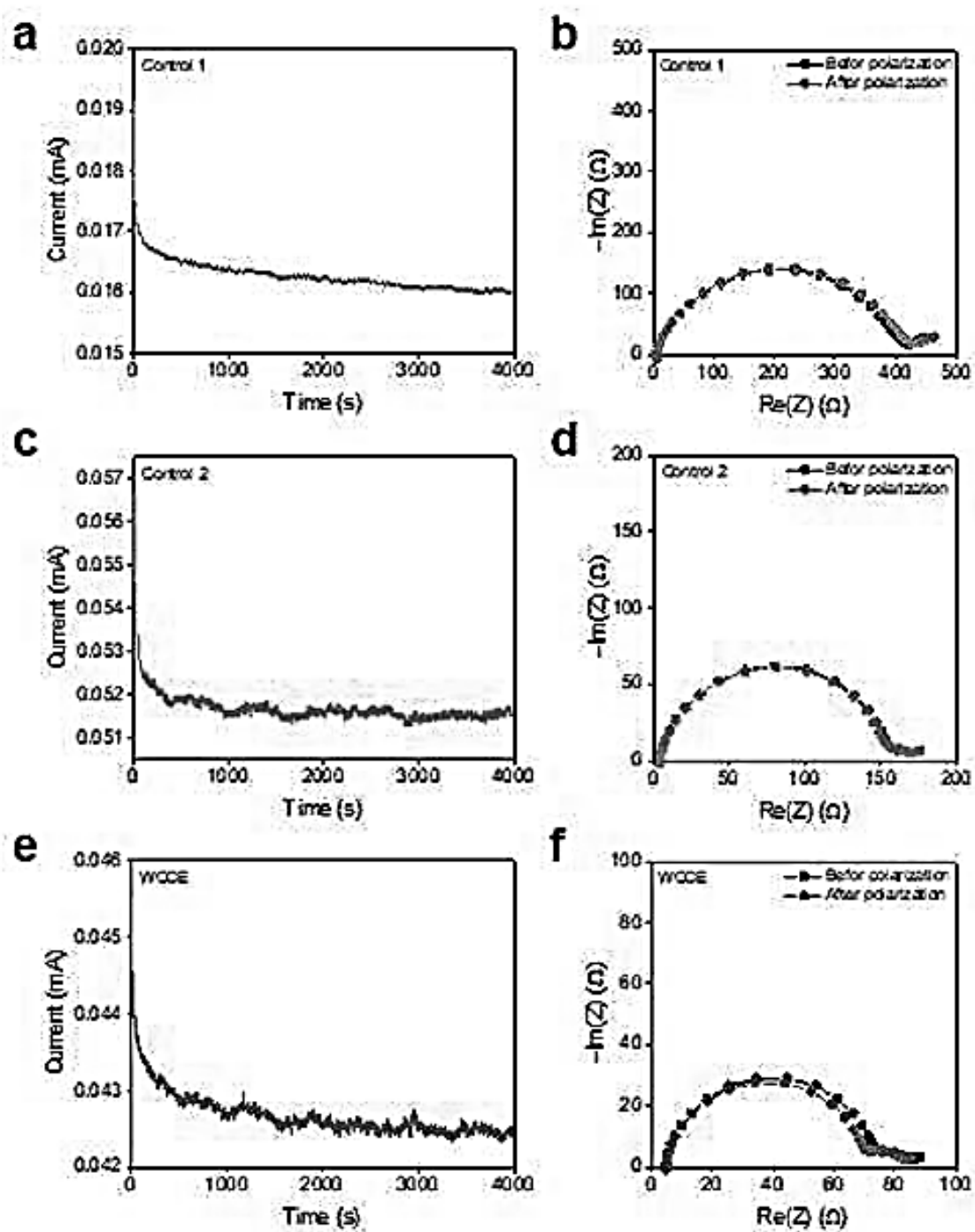
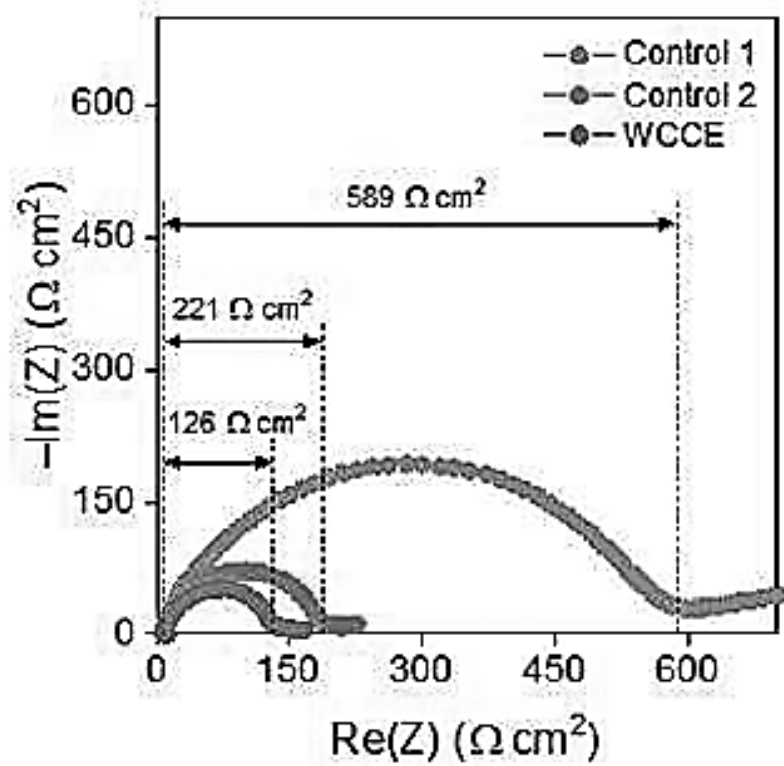


FIG. 6



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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	606100-000005
		Application Number	
Title of Invention	CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF 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>			

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	606100-000005
		Application Number	
Title of Invention	CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF THE SAME		

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Address 1	#406, GS Caltex Industry-Academic Co Center			
Address 2	50 Yonsei-ro, 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; border: 1px solid black; padding: 2px 5px;">Add</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	78198		
Email Address	info@sbspatentlaw.com	<div style="border: 1px solid black; padding: 2px 5px;">Add Email</div>	<div style="border: 1px solid black; padding: 2px 5px;">Remove Email</div>

Application Information:

Title of the Invention	CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF THE SAME		
Attorney Docket Number	606100-000005	Small Entity Status Claimed	<input checked="" type="checkbox"/>
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	6	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 ⁱ

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	606100-000005
		Application Number	
Title of Invention	CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF THE SAME		

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:

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.											
<table border="1"> <tr> <td>Please Select One:</td> <td><input checked="" type="radio"/> Customer Number</td> <td><input type="radio"/> US Patent Practitioner</td> <td><input type="radio"/> Limited Recognition (37 CFR 11.9)</td> </tr> <tr> <td>Customer Number</td> <td colspan="3">78198</td> </tr> </table>				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	78198		
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	78198										

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).

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	606100-000005
		Application Number	
Title of Invention	CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF THE SAME		

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	<div>Remove</div> Access Code ⁱ (if applicable)
10-2024-0085071	KR	2024-06-28	FE10
Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	<div>Remove</div> Access Code ⁱ (if applicable)
10-2025-0084205	KR	2025-06-25	1460
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	606100-000005
		Application Number	
Title of Invention	CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF 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	606100-000005
		Application Number	
Title of Invention	CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF 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

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.

[Clear](#)

☒ Assignee
 ☐ Legal Representative under 35 U.S.C. 117
 ☐ Joint Inventor

☐ Person to whom the inventor is obligated to assign.
 ☐ 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:

If the Applicant is an Organization check here. ☒

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	606100-000005
		Application Number	
Title of Invention	CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF 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	/Sang Yoon Kang/		Date (YYYY-MM-DD)	2025-06-27	
First Name	Sang Yoon	Last Name	Kang	Registration Number	75,762

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

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	606100-000005
		Application Number	
Title of Invention	CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF 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.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

- 1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
- 2 A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
- 3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
- 4 A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
- 5 A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
- 6 A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
- 7 A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
- 8 A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
- 9 A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number		
	Filing Date		2025-06-27
	First Named Inventor	Sang-Young LEE	
	Art Unit		
	Examiner Name		
	Attorney Docket Number	606100-000005	

U.S. PATENTS						
Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Inventor 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 Inventor 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	10-1705393	KR	B1	2017-02-09	Societe d'Exploitation de Produits Pour les Indust		<input checked="" type="checkbox"/>

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

NON-PATENT LITERATURE DOCUMENTS			
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

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number		
	Filing Date		2025-06-27
	First Named Inventor	Sang-Young LEE	
	Art Unit		
	Examiner Name		
	Attorney Docket Number		606100-000005

	1		<input type="checkbox"/>
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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 and 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

Application Number	
Filing Date	2025-06-27
First Named Inventor	Sang-Young LEE
Art Unit	
Examiner Name	
Attorney Docket Number	606100-000005

TIMING 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 timing statement under 37 CFR 1.97(e).
- ☒ A timing statement under 37 CFR 1.97(e) is not submitted herewith.

TIMING 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.

SIZE FEE ASSERTION

Please see 37 CFR 1.17(v) and the [IDS Auto-Load Instructions](#) for completing this form to make the appropriate selection of an assertion under 37 CFR 1.98. For the information disclosure statement (IDS) submitted herewith, the applicant or patent owner certifies the following with respect to the cumulative number of applicant-provided or patent-owner provided items of information submitted to date including those in the accompanying IDS (select only one):

- ☒ No IDS size fee is required under 37 CFR 1.17(v) at this time.
- ☐ The IDS is accompanied by the IDS size fee under 37 CFR 1.17(v)(1).
- ☐ The IDS is accompanied by the IDS size fee under 37 CFR 1.17(v)(2).
- ☐ The IDS is accompanied by the IDS size fee under 37 CFR 1.17(v)(3).

SIGNATURE

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 11.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Sang Yoon Kang/	Date (YYYY-MM-DD)	2025-06-27
Name/Print	Sang Yoon Kang	Registration Number	75,762

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

Application Number		
Filing Date		2025-06-27
First Named Inventor	Sang-Young LEE	
Art Unit		
Examiner Name		
Attorney Docket Number		606100-000005

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.**

Privacy Act Statement

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

**COMBINED DECLARATION (37 CFR 1.63) AND ASSIGNMENT FOR UTILITY OR
DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)**

Title of Invention	CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF THE SAME
-------------------------------	---

As the below named inventor, I hereby declare that:

This declaration is directed to: ☒ The attached application, or
☐ United States application or PCT international application number _____
filed on _____

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WHEREAS, UIF (University Industry Foundation), Yonsei University of 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, REPUBLIC OF KOREA, hereinafter referred to as the assignee, is desirous of acquiring the entire right, title and interest in and to said application, including any and all divisions and continuations thereof, and in and to said invention and any and all patents which may be granted therefor, including any and all renewals, reissues and prolongations thereof;

NOW, that for and in consideration of One Dollar (\$1.00), and other good and valuable consideration paid by said assignee to me, the receipt of which is hereby acknowledged, I hereby assign, sell and transfer to said assignee, and said assignee's successors and assigns, the full and exclusive right, title and interest in and to said application, including any and all divisions and continuations thereof, and in and to said invention for the United States of America and its territories and for all foreign countries, and any and all patents which may be granted therefor, in the United States of America and its territories and in all foreign countries, including any and all renewals, reissues and prolongations thereof; said assignee, and said assignee's successors and assigns, to have, hold, exercise and enjoy the said application, including any and all divisions and continuations thereof, and the said invention and any and all patents which may be granted therefor, including any and all renewals, reissues and prolongations thereof, with all the rights, powers, privileges and advantages in anywise arising from or appertaining thereto, for and during the term or terms of any and all such patents when granted, including any and all renewals, reissues and prolongations thereof, for the use and benefit of said assignee, and said assignee's successors and assigns, in as ample and beneficial a manner as I might or could have held and enjoyed the same, if this assignment had not been made.

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Inventor: LEE, Sang-Young Date: June 26, 2025

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Date: June 26, 2025

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Application Number	Not Yet Assigned
Filing Date	June 27, 2025
First Named Inventor	Sang-Young LEE
Title	CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF THE SAME
Art Unit	
Examiner Name	
Attorney Docket Number	606100-000005

SIGNATURE of Applicant or Patent Practitioner

Signature	/Sang Yoon Kang/	Date (Optional)	June 27, 2025
Name	Sang Yoon Kang	Registration Number	75,762
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.



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PTO/AIA/82B (07-13)

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Signature

Jongil Hong

Date (Optional)

March 18, 2024

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NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.



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	Filing Date	June 27, 2025
	First Named Inventor	Sang-Young LEE
	Art Unit	
	Examiner Name	
	Practitioner Docket No.	606100-000005

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I am the

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/Sang Yoon Kang/
Signature

June 27, 2025
Date

Sang Yoon Kang
Typed or printed name

(703) 390-9051
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CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Korean Patent Application No. 10-2024-0085071 filed on June 28, 2024 and Korean Patent Application No. 10-2025-0084205 filed on June 25, 2025 and all the benefits accruing therefrom under 35 U.S.C. § 119, the contents of which are incorporated by reference in their entirety.

BACKGROUND

[0002] Lithium metal is attracting attention as a next-generation battery anode material due to its high theoretical capacity (3861 mAh g^{-1}) and low redox potential (-3.04 V vs. Standard hydrogen electrode). However, conventional liquid electrolytes are not well compatible with lithium metal anodes due to safety issues caused by high volatility and flammability, and liquid electrolytes are prone to depletion by continuously reacting with lithium metal anodes. Due to these problems, the transition to solid electrolytes for the use of lithium metal anodes is receiving significant attention. However, inorganic solid electrolytes represented by Argyrodite-type $\text{Li}_6\text{PS}_5\text{Cl}$ still have many unresolved problems such as low processability, poor interfacial contact, and reactivity with lithium metal.

[0003] As an alternative to this, polymer-based solid electrolytes, which have mild processing conditions and excellent compatibility with lithium metal, are being regarded as the most promising candidates as electrolytes for lithium metal batteries. However, most research on polymer electrolytes has focused on improving the low ionic conductivity compared to liquid

electrolytes and inorganic solid electrolytes, and studies dealing with interfacial properties that contribute more directly to the actual performance of lithium metal batteries are still insufficient. Research on the interfacial properties of polymer electrolytes with lithium metal has mainly focused on forming a robust solid electrolyte interphase (SEI) layer that is inorganic-rich (especially LiF-rich) and improving surface morphology by adopting early-stage liquid electrolyte research methods in the field, such as using an excessive amount of salt or introducing additives containing fluorine (F) groups.

[0004] Therefore, existing studies are limited to observing and partially improving the static state of lithium metal, and lack understanding and utilization of dynamic phenomena occurring at the actual interface.

SUMMARY

[0005] The present invention has been devised to solve the above-mentioned problems, and an object of the present invention is to provide a composition for preparing a polymer electrolyte, comprising a cationic monomer; a multifunctional monomer; a plastic crystal; and a lithium salt.

[0006] In addition, another object of the present invention is to provide a polymer electrolyte prepared using the above composition for preparing a polymer electrolyte.

[0007] In addition, another object of the present invention is to provide a lithium metal battery comprising the above polymer electrolyte.

[0008] Furthermore, another object of the present invention is to provide a device comprising the above lithium metal battery, wherein the device is selected from the group consisting of a communication device, a transportation device, and an energy storage device.

[0009] In addition, another object of the present invention is to provide a method for preparing a

polymer electrolyte, comprising:

[0010] (A) obtaining a composition for preparing a polymer electrolyte by mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt; and (B) preparing the polymer electrolyte by polymerizing the composition for preparing a polymer electrolyte.

[0011] The objects of the present invention are not limited to the purposes mentioned above, and other objects and advantages of the present invention that are not mentioned can be understood through the following description and will be more clearly understood through the embodiments of the present invention. In addition, it will be easily understood that the objects and advantages of the present invention can be achieved by the means and combinations thereof described in the specification.

[0012] One aspect of the present invention provides a composition for preparing a polymer electrolyte, comprising a cationic monomer; a multifunctional monomer; a plastic crystal; and a lithium salt.

[0013] The cationic monomer may comprise at least one selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium.

[0014] The cationic monomer may comprise a cationic functional group; and an anionic functional group.

[0015] The anionic functional group may be an imide compound functional group.

[0016] The multifunctional monomer may comprise at least one selected from the group consisting of trimethylolpropane propoxylate triacrylate (TPPTA), ethoxylated trimethylolpropane triacrylate (ETPTA), trimethylolpropane triacrylate (TMPTA), and poly(ethylene glycol) diacrylate (PEGDA).

[0017] The molar ratio of the cationic monomer to the multifunctional monomer may be from 70 to 90 : 30 to 10.

[0018] The plastic crystal may be at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile. The content of the plastic crystal may be from 58 to 83 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

[0019] The lithium salt may comprise at least one selected from the group consisting of lithium bis(trifluoromethanesulfonyl)imide (LiTFSI), lithium bis(pentafluoroethanesulfonyl)imide (LiBETI), and lithium bis(fluorosulfonyl)imide (LiFSI).

[0020] The content of the lithium salt may be from 35 to 65 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

[0021] The composition for preparing the polymer electrolyte may further comprise at least one additive selected from the group consisting of vinylene carbonate and fluoroethylene carbonate (FEC).

[0022] The content of the additive may be from 1 to 10 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

[0023] The composition for preparing the polymer electrolyte may further comprise an initiator.

[0024] Another aspect of the present invention provides a polymer electrolyte prepared using the composition for preparing the polymer electrolyte.

[0025] Another aspect of the present invention provides a lithium metal battery comprising the polymer electrolyte.

[0026] Another aspect of the present invention provides a device comprising the lithium metal battery, wherein the device is selected from the group consisting of a communication device, a

transportation device, and an energy storage device.

[0027] Another aspect of the present invention provides a method for preparing a polymer electrolyte, comprising:

[0028] (A) obtaining a composition for preparing a polymer electrolyte by mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt; and (B) preparing the polymer electrolyte by polymerizing the composition for preparing the polymer electrolyte.

[0029] The polymerization may be performed at a temperature of 58 to 95°C for 1 to 7 hours.

[0030] The means for solving the above problems do not enumerate all features of the present invention, and may be combined with certain embodiments described in the present specification. Various features of the present invention and the advantages and effects thereof can be understood in more detail with reference to the following detailed description.

[0031] The polymer electrolyte of the present invention exhibits excellent ion transport properties.

[0032] In addition to the above-described effects, specific effects of the present invention will be described together while explaining specific details for carrying out the invention below. Furthermore, the effects of the present invention are not limited to the effects mentioned above, and can be easily realized by the means and combinations thereof described in the specification

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] FIG. 1 is a schematic view illustrating the structure and dynamic response of a polymer electrolyte (WCCE, Control 2) according to one embodiment of the present invention and a polymer electrolyte (Control 1) in which a neutral polymer (matrix) is introduced.

[0034] FIG. 2 shows (a) a schematic diagram illustrating the molecular interactions in a polymer electrolyte (Control 1) in which a neutral polymer (matrix) is introduced and a polymer electrolyte (WCCE, Control 2) according to one embodiment of the present invention, and (b) FT-IR spectra, (c) ^{15}N NMR spectra, and (d) ^7Li NMR spectra of the polymer electrolytes prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[0035] FIG. 3 shows (a) the Tafel slope, (b) voltage profiles (current density = 0.1 mA cm^{-2} / capacity = 0.1 mA cm^{-2}), and (c) voltage profiles (increased from 0.1 mA cm^{-2} to 1.5 mA cm^{-2} at a rate of $0.1 \text{ mA cm}^{-2} \text{ h}^{-1}$) of lithium metal batteries ($\text{Li}||\text{Li}$ cells) prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention, and (d)–(f) scanning electron microscope (SEM) images of the lithium metal anodes in the lithium metal batteries prepared in (d) Comparative Example 1 (Control 1), (e) Example 2 (Control 2), and (f) Example 1 (WCCE).

[0036] FIG. 4 shows the Nyquist plot of $\text{SUS}||\text{SUS}$ cells prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[0037] FIG. 5 shows the current–time graphs (left) and Nyquist plots (right) under 10 mV polarization of lithium metal batteries ($\text{Li}||\text{Li}$ symmetric cells) prepared in (a, b) Comparative Example 1 (Control 1), (c, d) Example 2 (Control 2), and (e, f) Example 1 (WCCE) of the present invention.

[0038] FIG. 6 shows the Nyquist plots of lithium metal batteries prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0039] In the present specification, a singular expression includes a plural expression unless the context clearly indicates otherwise.

[0040] In the present specification, a numerical range indicated by the term "to" represents a

numerical range including the values stated before and after the term as the lower and upper limits, respectively. For example, when “a to b” is described in the specification, it can be understood as meaning a range from a to b, inclusive.

[0041] In the present specification, when a plurality of numerical values are disclosed as the lower and upper limits of a numerical range, the numerical range disclosed in the specification can be understood as any numerical range having any one of the plurality of lower limit values and any one of the plurality of upper limit values as the lower limit and upper limit, respectively. For example, when “not less than a” or “not less than b”; and “not more than c” or “not more than d” are described, it can be understood as meaning “not less than a and not more than c,” “not less than a and not more than d,” “not less than b and not more than c,” or “not less than b and not more than d.”

[0042] One aspect of the present invention provides a composition for preparing a polymer electrolyte, comprising a cationic monomer; a multifunctional monomer; a plastic crystal; and a lithium salt.

[0043] When applied as a polymer electrolyte, the composition for preparing a polymer electrolyte according to the present invention exhibits dominant weak attractive interactions between the metal ion (Li^+) and the solvent (or anion) due to the double coordination structure consisting of metal ion–solvent (or anion)–cationic polymer (polymerized from cationic monomer). Accordingly, since the metal ion has a primary coordination structure formed with the mobile phase solvent or anion, without directly interacting with the stationary phase cationic polymer matrix, the ion transport property in the bulk electrolyte is improved. In addition, due to the double coordination structure, the binding energy between the metal ion and the solvent (or anion) is reduced, thereby facilitating de-coordination of the metal ion at the electrolyte/electrode interface during battery charging, which reduces interfacial charge transfer resistance and suppresses lithium

dendrite growth.

[0044] The present invention is characterized in that a polymer polymerized from a cationic monomer is used as the matrix of the polymer electrolyte, which, unlike neutral monomers and neutral polymers, is capable of directly interacting with the plastic crystal. This interaction reduces the lithium ion coordination ability of the plastic crystal that coordinates lithium ions in the electrolyte, thereby improving the lithium ion de-coordination kinetics at the interface (regulation of static lithium ion coordination structure), increasing ionic conductivity, and reducing charge transfer resistance at the electrode surface.

[0045] The cationic monomer may comprise at least one selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium; preferably, may comprise imidazolium; more preferably, may comprise imidazolium in which a methyl group is introduced at the 3-position of the imidazolium ring; and most preferably, may comprise 1-allyl-3-methylimidazolium.

[0046] The cationic monomer may be a salt compound comprising a cationic functional group; and an anionic functional group. The salt compound may refer to an ionic compound in which the cation and the anion are electrostatically bound to each other to exhibit a neutral state.

[0047] According to one embodiment of the present invention, in the case of the cationic monomer, the presence of a counter anion is essential, and therefore, the cationic functional group may be present together with a counter anion.

[0048] The features described in the above-described embodiment may be combined with other embodiments unless explicitly described otherwise. Although the preferred embodiments of the present invention have been described in detail above, the scope of the present invention is not limited thereto, and various modifications and improvements made by those skilled in the art using

the basic concept of the present invention defined in the following claims also fall within the scope of the present invention.

[0049] The cationic functional group may be at least one functional group selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium; preferably, the cationic functional group may be an imidazolium functional group; more preferably, the functional group may be a functional group in which a methyl group is introduced at the 3-position of the imidazolium ring; and most preferably, the functional group may be a 1-allyl-3-methylimidazolium functional group.

[0050] In particular, it is most preferable when the cationic monomer comprises a compound of 1-allyl-3-methylimidazolium or a functional group thereof, as the chemical stability can be significantly increased.

[0051] The anionic functional group may be an imide compound functional group, and more preferably, may be a bis(trifluoromethanesulfonyl)imide functional group. In particular, bis(trifluoromethanesulfonyl)imide is more preferably used as an anionic functional group, since it facilitates salt dissociation and forms F-containing decomposition products at the electrode, which can increase reversibility.

[0052] According to a preferred embodiment of the present invention, the cationic monomer may be 1-allyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (AMIM-TFSI). In particular, AMIM-TFSI is most preferable, since unlike other cationic monomers, it can reduce charge transfer resistance by at least 10%.

[0053] The multifunctional monomer may be a compound having a polymerizable functional group capable of bonding with the cationic monomer, and preferably, may be a multifunctional monomer having two or more of the polymerizable functional groups.

[0054] The polymerizable functional group may be an acryl group.

[0055] The polymerizable functional group may react and bond with the cationic functional group of the cationic monomer to interconnect the cationic monomers and form a polymer.

[0056] The multifunctional monomer may comprise at least one selected from the group consisting of trimethylolpropane propoxylate triacrylate (TPPTA), ethoxylated trimethylolpropane triacrylate (ETPTA), trimethylolpropane triacrylate (TMPTA), and poly(ethylene glycol) diacrylate (PEGDA); preferably, may be a polyol ester-based acrylate compound; and more preferably, may be trimethylolpropane propoxylate triacrylate (TPPTA).

[0057] The cationic monomer and the multifunctional monomer are each present in the composition, but they are polymerized to form a polymer.

[0058] The molar ratio of the cationic monomer to the multifunctional monomer may be from 70 to 90 : 30 to 10, preferably from 73 to 87 : 27 to 13, more preferably from 75 to 85 : 25 to 15, and most preferably from 68 to 82 : 32 to 18.

[0059] When the cationic monomer and the multifunctional monomer are used outside the above molar ratio, the mechanical properties of the resulting polymer electrolyte may deteriorate, and a large number of defects may occur on the surface.

[0060] The plastic crystal increases the dielectric constant of the polymer electrolyte and weakens the bonding between the cationic polymer matrix, which is derived from the cationic monomer, and the metal ion.

[0061] The plastic crystal may be at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile.

[0062] The nitrile-based compound may be a nitrile-based compound having 2 to 5 carbon atoms, excluding the nitrile group within the molecule. Nitrile-based compounds having more than 5 carbon atoms are not suitable for use in electrolytes due to their solid phase or high viscosity.

[0063] The content of the plastic crystal may be from 58 to 83 parts by weight, preferably from 60 to 80 parts by weight, more preferably from 62 to 77 parts by weight, and most preferably from 65 to 75 parts by weight, based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer (thermosetting composition).

[0064] When the plastic crystal is used in an amount smaller than the above range based on 100 parts by weight of the thermosetting composition, the ionic conductivity may significantly decrease, and lithium dendrites may be generated even without prolonged cycling. On the other hand, when used in an excessive amount, the crosslinking density of the polymer electrolyte may decrease, and it may fail to exhibit solid-state properties.

[0065] In addition, the composition for preparing the polymer electrolyte of the present invention is characterized in that a lithium salt is used together with the plastic crystal, and the plastic crystal, in the presence of the lithium salt, becomes liquid, thereby making the polymer electrolyte prepared using the same into a gel electrolyte.

[0066] The lithium salt may comprise at least one selected from the group consisting of lithium bis(trifluoromethanesulfonyl)imide (LiTFSI), lithium bis(pentafluoroethanesulfonyl)imide (LiBETI), and lithium bis(fluorosulfonyl)imide (LiFSI); preferably, the lithium salt may be lithium bis(fluorosulfonyl)imide (LiFSI, $\text{LiF}_2\text{NO}_4\text{S}_2$).

[0067] The content of the lithium salt may be from 35 to 65 parts by weight, preferably from 37 to 63 parts by weight, more preferably from 40 to 60 parts by weight, and most preferably from 45 to 55 parts by weight, based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer (thermosetting composition).

[0068] When the lithium salt is used in an amount smaller than the above range based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer (thermosetting composition), dynamic lithium ion coordination structure regulation may not be

achieved, and the effect of reducing interfacial charge transfer resistance may fall short of expectations. On the other hand, when used in an excessive amount, the lithium ion conductivity of the polymer electrolyte may be significantly decreased.

[0069] In particular, the composition for preparing a polymer electrolyte of the present invention can increase the content of the lithium salt up to the solubility limit to increase the proportion of anions included in the primary coordination structure within the polymer electrolyte. As a result, the Li^+ coordination energy is reduced, and during charging, the lithium metal anode becomes negatively polarized, causing repulsion of anions from the surface. This further reduces the Li^+ coordination energy at the electrolyte/anode interface, thereby facilitating Li^+ de-coordination during charging and further reducing interfacial charge transfer resistance, which suppresses lithium dendrite growth. In addition, it promotes the decomposition of anions at the lithium metal anode, forming a LiF-rich SEI to stabilize the interface and further suppress lithium dendrite growth.

[0070] According to a preferred embodiment of the present invention, the cationic monomer is 1-allyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide (AMIM-TFSI), the multifunctional monomer is trimethylolpropane propoxylate triacrylate (TPPTA), and the plastic crystal may be at least one selected from the group consisting of succinonitrile (butanedinitrile, $\text{C}_2\text{H}_4(\text{CN})_2$), glutaronitrile, and adiponitrile.

[0071] When the composition for preparing a polymer electrolyte of the present invention satisfies all the components according to the preferred embodiment, it was confirmed that it is more preferable in that, even after 250 charge-discharge cycles using a lithium metal battery prepared with the polymer electrolyte produced therefrom, no defects occurred on the surface of the polymer electrolyte. However, when any one of the components of the preferred embodiment was not satisfied, defects were generated on the surface of the polymer electrolyte after 250 charge-

discharge cycles.

[0072] According to another preferred embodiment of the present invention, the molar ratio of the cationic monomer to the multifunctional monomer is 68 to 82 : 32 to 18, the content of the plastic crystal is from 65 to 75 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer, and the lithium salt may be from 45 to 55 parts by weight.

[0073] When the composition of the composition for preparing a polymer electrolyte of the present invention satisfies all the numerical ranges of the above-described another preferred embodiment, it was confirmed that the mechanical properties and surface uniformity of the polymer electrolyte, prepared using the composition and applied to a lithium metal battery, were maintained the same as the initial state even after 250 charge-discharge cycles. However, when any one of the compositional ranges of the another preferred embodiment was not satisfied, the surface uniformity was degraded compared to the initial state after 250 charge-discharge cycles, and the mechanical properties decreased by at least 7%.

[0074] The composition for preparing the polymer electrolyte may further comprise an additive.

[0075] The additive serves to stabilize the surface of the lithium metal, and specifically, may be at least one selected from the group consisting of vinylene carbonate and fluoroethylene carbonate (FEC); preferably, the additive may be fluoroethylene carbonate (FEC).

[0076] The content of the additive may be from 1 to 10 parts by weight, preferably from 2 to 7 parts by weight, based on 100 parts by weight of the thermosetting composition.

[0077] When the additive is used in an amount smaller than the above range based on 100 parts by weight of the thermosetting composition, stabilization of the lithium metal anode may be difficult. On the other hand, when used in an excessive amount, the additive may decompose itself excessively, thereby lowering the Coulombic efficiency.

[0078] The composition for preparing the polymer electrolyte may further comprise an initiator.

[0079] The initiator induces a polymerization reaction of the cationic monomer and the multifunctional monomer to form a polymer.

[0080] The initiator is not particularly limited as long as it is a substance that induces the polymerization reaction of the cationic monomer and the multifunctional monomer, and in one embodiment, it may be 2,2'-azobis(2-methylpropionitrile) (AIBN).

[0081] The content of the initiator may be from 0.05 to 10 parts by weight, preferably from 0.1 to 7 parts by weight, based on 100 parts by weight of the thermosetting composition.

[0082] When the initiator is used in an amount smaller than the above range based on 100 parts by weight of the thermosetting composition, the polymer may not be sufficiently formed. On the other hand, when used in an excessive amount, it may cause side reactions in the battery and deteriorate battery performance.

[0083] Another aspect of the present invention provides a polymer electrolyte prepared using the composition for preparing the polymer electrolyte.

[0084] The polymer electrolyte may be prepared by polymerizing the composition for preparing the polymer electrolyte, and the polymerization may be thermal polymerization or photopolymerization.

[0085] The polymer electrolyte may comprise a cationic polymer matrix polymerized from a thermosetting composition comprising the cationic monomer and the multifunctional monomer.

[0086] The room temperature ionic conductivity of the polymer electrolyte may be from 1.2×10^{-3} to 2.1×10^{-3} S/cm, and the room temperature charge transfer resistance may be from 30 to 50 Ω .

[0087] FIG. 1 is a schematic diagram illustrating the structure and dynamic response of a polymer electrolyte (WCCE, Control 2) according to one embodiment of the present invention and a polymer electrolyte (Control 1) in which a neutral polymer (matrix) is introduced.

[0088] As shown in FIG. 1, the polymer electrolyte (Control 1) in which a neutral polymer (matrix) is introduced exhibits strong interaction between the metal (lithium) and the neutral polymer, making ion transport difficult and limiting metal plating/stripping. Even when a plastic crystal is further added, the plastic crystal also strongly interacts with the metal, thereby further restricting the metal plating/stripping.

[0089] In addition, the polymer electrolyte (WCCE, Control 2) according to one embodiment of the present invention allows regulation of a static coordination structure due to the double coordination structure of metal ion (Li^+)–solvent (or anion)–cationic polymer. As a result, Li^+ does not directly interact with the stationary phase cationic polymer matrix but instead forms a primary coordination structure with the mobile phase solvent or anion, thereby improving ion transport properties in the bulk electrolyte. Furthermore, the binding energy between Li^+ and the solvent (or anion) is reduced, facilitating Li^+ de-coordination at the electrolyte/anode interface during charging.

[0090] In addition, the WCCE has a higher concentration of lithium salt than the polymer electrolyte (Control 2) in which the cationic polymer is introduced. By increasing the concentration of the lithium salt, the proportion of anions in the primary coordination structure is further increased, thereby achieving additional reduction in binding energy through utilization of anion repulsion at the lithium metal anode interface during charging, and accomplishing regulation of both static and dynamic coordination structures.

[0091] In addition, the present invention provides a lithium metal battery comprising the polymer electrolyte.

[0092] Furthermore, the present invention provides a device comprising the lithium metal battery, wherein the device is selected from the group consisting of a communication device, a transportation device, and an energy storage device.

[0093] Another aspect of the present invention provides a method for preparing a polymer electrolyte, comprising:

[0094] (A) obtaining a composition for preparing a polymer electrolyte by mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt; and (B) preparing the polymer electrolyte by polymerizing the composition for preparing the polymer electrolyte.

[0095] (A) obtaining a composition for preparing a polymer electrolyte by mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt

[0096] The step (A) is a step of obtaining a composition for preparing a polymer electrolyte by mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt.

[0097] The cationic monomer may comprise at least one selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium; preferably, may comprise imidazolium; more preferably, may comprise imidazolium in which a methyl group is introduced at the 3-position of the imidazolium ring; and most preferably, may comprise 1-allyl-3-methylimidazolium.

[0098] The cationic monomer may be a salt compound comprising a cationic functional group; and an anionic functional group.

[0099] The cationic functional group may be at least one functional group selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium; preferably, may be an imidazolium functional group; more preferably, may be a functional group in which a methyl group is introduced at the 3-position of the imidazolium ring; and most preferably, may be a 1-allyl-3-methylimidazolium functional group.

[00100] The anionic functional group may be an imide compound functional group, and

more preferably, may be a bis(trifluoromethanesulfonyl)imide functional group.

[00101] According to a preferred embodiment of the present invention, the cationic monomer may be 1-allyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide (AMIM-TFSI).

[00102] The multifunctional monomer may be a compound having a polymerizable functional group capable of bonding with the cationic monomer, and preferably, may be a multifunctional monomer having two or more of the polymerizable functional groups.

[00103] The polymerizable functional group may be an acryl group.

[00104] The polymerizable functional group may react and bond with the cationic functional group of the cationic monomer to interconnect the cationic monomers and form a polymer.

[00105] The multifunctional monomer may be an acrylate compound, preferably a polyol ester-based acrylate compound, and more preferably, trimethylolpropane propoxylate triacrylate (TPPTA).

[00106] The cationic monomer and the multifunctional monomer are each present in the composition, but they are polymerized to form a polymer.

[00107] The molar ratio of the cationic monomer to the multifunctional monomer may be from 70 to 90 : 30 to 10, preferably from 73 to 87 : 27 to 13, more preferably from 75 to 85 : 25 to 15, and most preferably from 68 to 82 : 32 to 18.

[00108] The plastic crystal may be at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile.

[00109] The content of the plastic crystal may be from 58 to 83 parts by weight, preferably from 60 to 80 parts by weight, more preferably from 62 to 77 parts by weight, and most preferably from 65 to 75 parts by weight, based on 100 parts by weight of the total of the cationic monomer

and the multifunctional monomer (thermosetting composition).

[00110] The lithium salt may comprise at least one selected from the group consisting of lithium bis(trifluoromethanesulfonyl)imide (LiTFSI), lithium bis(pentafluoroethanesulfonyl)imide (LiBETI), and lithium bis(fluorosulfonyl)imide (LiFSI); preferably, the lithium salt may be lithium bis(fluorosulfonyl)imide (LiFSI, LiF₂NO₄S₂).

[00111] The content of the lithium salt may be from 35 to 65 parts by weight, preferably from 37 to 63 parts by weight, more preferably from 40 to 60 parts by weight, and most preferably from 45 to 55 parts by weight, based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer (thermosetting composition).

[00112] The composition for preparing the polymer electrolyte may further comprise an additive.

[00113] The additive may be at least one selected from the group consisting of vinylene carbonate and fluoroethylene carbonate (FEC); preferably, the additive may be fluoroethylene carbonate (FEC).

[00114] The content of the additive may be from 1 to 10 parts by weight, preferably from 2 to 7 parts by weight, based on 100 parts by weight of the thermosetting composition.

[00115] The composition for preparing the polymer electrolyte may further comprise an initiator.

[00116] The initiator may be 2,2'-azobis(2-methylpropionitrile) (AIBN). The content of the initiator may be from 0.05 to 10 parts by weight, preferably from 0.1 to 7 parts by weight, based on 100 parts by weight of the thermosetting composition.

[00117] (B) preparing the polymer electrolyte by polymerizing the composition for preparing the polymer electrolyte

[00118] The step (B) is a step of preparing a polymer electrolyte by polymerizing the composition for preparing the polymer electrolyte.

[00119] In the step (B), a polymer may be polymerized from a thermosetting composition comprising the cationic monomer and the multifunctional monomer.

[00120] The polymerization may be thermal polymerization or photopolymerization.

[00121] The thermal polymerization may be performed at a temperature of 58 to 95°C for 1 to 7 hours, preferably at 60 to 90°C for 2 to 6 hours, more preferably at 63 to 85°C for 2.3 to 5 hours, and most preferably at 65 to 78°C for 2.5 to 4 hours.

[00122] When either the temperature or time of the thermal polymerization is below the lower limit, the mechanical properties of the polymer electrolyte may deteriorate, and conversely, when either exceeds the upper limit, a large amount of by-products may be generated. When either the temperature or time of the thermal polymerization is below the lower limit, the mechanical properties of the polymer electrolyte may deteriorate, and conversely, when either exceeds the upper limit, a large amount of by-products may be generated.

[00123] Although not explicitly described in the following examples and comparative examples, after preparing a polymer electrolyte by varying the following conditions in the method for preparing the polymer electrolyte of the present invention, a lithium metal battery was prepared using the polymer electrolyte, and subjected to 800 charge-discharge cycles by conventional methods.

[00124] As a result, when all the following conditions were satisfied, lithium dendrites were not formed at all even after 250 charge-discharge cycles, and the ionic conductivity and interfacial charge transfer resistance characteristics were maintained at the same level as initially, confirming that long-term stability was particularly excellent.

[00125] However, when any one of the following conditions is not satisfied, lithium

dendrites were observed starting from up to 250 charge-discharge cycles, or the ionic conductivity and interfacial charge transfer resistance characteristics decreased by 8% or more compared to the initial state, resulting in somewhat reduced long-term stability.

[00126] (1) The cationic monomer is 1-allyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide (AMIM-TFSI);

[00127] (2) The multifunctional monomer is trimethylolpropane propoxylate triacrylate (TPPTA);

[00128] (3) The molar ratio of the cationic monomer to the multifunctional monomer is from 68 to 82 : 32 to 18;

[00129] (4) The plastic crystal is at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile;

[00130] (5) The content of the plastic crystal is from 65 to 75 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer;

[00131] (6) The content of the lithium salt is from 45 to 55 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer;

[00132] (7) The composition for preparing the polymer electrolyte further comprises fluoroethylene carbonate (FEC);

[00133] (8) The content of fluoroethylene carbonate (FEC) is from 2 to 7 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer; and

[00134] (9) The polymerization may be performed at 65 to 78°C for 2.5 to 4 hours.

[00135] The present invention will be described in more detail below through examples and the like; however, the scope and content of the present invention should not be interpreted as being limited or restricted by the examples and the like described below.

[00136] Example 1. Weakly coordinating cationic polymer electrolyte (WCCE) and a lithium metal battery comprising the same

[00137] A precursor solution was prepared by mixing a cationic monomer (1-allyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (AMIM-TFSI)), a crosslinker (trimethylolpropane propoxylate triacrylate (TPPTA)), a plastic crystal (succinonitrile, SN), a lithium salt (lithium bis(fluorosulfonyl)imide (LiFSI)), an additive (fluoroethylene carbonate (FEC)), and an initiator (2,2'-azobis(2-methylpropionitrile) (AIBN)) at a weight ratio of 100 : 40 : 100 : 72 : 6 : 0.5.

[00138] At this time, the molar ratio of the cationic monomer to the crosslinker was 80 : 20.

[00139] Then, after injecting the precursor solution into the cell and assembling it, the lithium metal battery including the polymer electrolyte formed by an in situ method was prepared by heating at 70°C for 3 hours.

[00140] Example 2. Control 2

[00141] A precursor solution was prepared by mixing a cationic monomer (1-allyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (AMIM-TFSI)), a crosslinker (trimethylolpropane propoxylate triacrylate (TPPTA)), a plastic crystal (succinonitrile, SN), a lithium salt (lithium bis(fluorosulfonyl)imide (LiFSI)), an additive (fluoroethylene carbonate (FEC)), and an initiator (2,2'-azobis(2-methylpropionitrile) (AIBN)) at a weight ratio of 100 : 40 : 100 : 29 : 5.5 : 0.5. At this time, the molar ratio of the cationic monomer to the crosslinker was 80 : 20.

[00142] Then, after injecting the precursor solution into the cell and assembling it, the

lithium metal battery including the polymer electrolyte formed by an in situ method was prepared by heating at 70°C for 3 hours.

[00143] Comparative Example 1. Control 1

[00144] A precursor solution was prepared by mixing a neutral monomer (trimethylolpropane 1-allylimidazole), a crosslinker (trimethylolpropane propoxylate triacrylate (TPPTA)), a plastic crystal (succinonitrile, SN), a lithium salt (lithium bis(fluorosulfonyl)imide (LiFSI)), an additive (fluoroethylene carbonate (FEC)), and an initiator (2,2'-azobis(2-methylpropionitrile) (AIBN)) at a weight ratio of 100 : 149 : 370 : 108 : 15 : 2. At this time, the molar ratio of the neutral monomer to the crosslinker was 80 : 20.

[00145] Then, after injecting the precursor solution into the cell and assembling it, the lithium metal battery including the polymer electrolyte formed by an in situ method was prepared by heating at 70°C for 3 hours.

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[00146] Experimental Example 1. Coordination Energy Analysis

[00147] FIG. 2 shows (a) a schematic diagram illustrating the interactions of molecules within a polymer electrolyte (Control 1) in which a neutral polymer (matrix) is introduced and a polymer electrolyte (WCCE, Control 2) according to one embodiment of the present invention, and (b) FT-IR spectra, (c) ¹⁵N NMR spectra, and (d) ⁷Li NMR spectra of polymer electrolytes prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[00148] As shown in (b) of FIG. 2, in Example 1 (WCCE) and Example 2 (Control 2), which include the cationic monomer, the nitrile (in SN)-Li⁺ interaction is weakened, reducing the degree to which nitrile (in SN) donates electron density to Li⁺. As a result, the C≡N bond strength

(in SN) increased, and the FT-IR peak corresponding to coordinating SN due to mutual coordination was detected at a higher wavenumber (2280 cm^{-1} vs. 2276 cm^{-1}) compared to Comparative Example 1 (Control 1).

[00149] As shown in (c) of FIG. 2, the lithium ion coordination is statically regulated, resulting in a decrease in the degree to which nitrile donates electron density to Li^+ . This causes localization of electrons in the nitrile group, and it was confirmed that the peak of the nitrile group was shielded in the ^{15}N NMR spectrum.

[00150] As shown in (d) of FIG. 2, in Example 1 (WCCE) and Example 2 (Control 2), which include the cationic monomer, the presence of mutual coordination decreases the coordinating ability of the ligand, increasing the proportion of anions within the Li^+ coordination sheath. As a result, lithium ion coordination is statically regulated, and an upshift of the Li^+ peak was observed in the ^7Li NMR spectrum.

[00151] In addition, compared to Example 2 (Control 2), Example 1 (WCCE) showed an upshift of the Li^+ peak due to the effect of mutual coordination and an increased ion pairing effect resulting from the introduction of a high concentration lithium salt. That is, as shown in FIG. 2, with the introduction of the cationic monomer, the interaction between lithium ions and the plastic crystal is weakened, resulting in an increase in the bond strength of the nitrile bond in the plastic crystal (succinonitrile).

[00152] Experimental Example 2. Electrochemical Performance Evaluation

[00153] The electrochemical performance of lithium metal batteries prepared in Example 1 and Comparative Examples 1 to 2 was evaluated, and the results are shown in (a) to (c) of FIG. 3.

[00154] FIG. 3 shows (a) the Tafel slopes, (b) the voltage profiles (current density = 0.1

mA/cm², capacity = 0.1 mA/cm²), and (c) the voltage profiles (current density increased from 0.1 mA/cm² to 1.5 mA/cm² at a rate of 0.1 mA/cm²·h⁻¹) of lithium metal batteries (Li||Li cells) prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[00155] As shown in (a) of FIG. 3, in Examples 1 and 2, lithium ion de-coordination is promoted, improving the kinetics of the electrochemical reaction, resulting in higher exchange current density compared to the comparative example.

[00156] As shown in (b) of FIG. 3, compared to the comparative example, the examples exhibited lower overvoltage and superior lifetime characteristics due to improved electrochemical reaction kinetics. In particular, among the examples, Example 1 exhibited an overvoltage of 15 mV or less for more than 1000 hours at a current density of 0.1 mA/cm² and a capacity of 0.1 mA/cm².

[00157] As shown in (c) of FIG. 3, the examples exhibit a higher limiting current density based on improved electrochemical reaction kinetics compared to the comparative examples.

[00158] Experimental Example 3. Surface Evaluation

[00159] In order to demonstrate the Li plating/stripping stability of lithium metal batteries prepared in Example 1 and Comparative Examples 1 to 2, the surface morphology of the lithium metal anode after 50 cycles at a current density of 0.1 mA/cm² and a capacity of 0.1 mAh/cm² was analyzed by scanning electron microscopy (SEM), and the results are shown in (d) to (f) of FIG. 3.

[00160] FIG. 3 shows scanning electron microscope (SEM) images of lithium metal anodes in lithium metal batteries prepared in (d) Comparative Example 1 (Control 1), (e) Example 2 (Control 2), and (f) Example 1 (WCCE) of the present invention.

[00161] As shown in (d) to (f) of FIG. 3, the lithium metal anode of Comparative Example 1 exhibited dendrite formation with a porous surface, whereas Example 2, in which the coordination structure was partially regulated, formed a denser morphology with reduced dendrite growth. Example 1, in which all strategies capable of regulating the coordination structure were applied, induced the formation of the densest and dendrite-free uniform lithium metal surface morphology. This is because the low de-coordination energy barrier induces uniform lithium metal deposition, which is advantageous for forming a dense lithium metal surface with suppressed dendrite growth.

[00162] Experimental Example 4. Charge Transfer Characteristic Evaluation

[00163] The room temperature ionic conductivity of SUS||SUS cells prepared in Example 1 and Comparative Examples 1 to 2 was measured, and the results are shown in FIG. 4 and Table 1 below. FIG. 4 shows Nyquist plots of SUS||SUS cells prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[00164] The room temperature cationic yield (and lithium ion conductivity) of lithium metal batteries prepared in Example 1 and Comparative Examples 1 to 2 was measured, and the results are shown in FIG. 5 and Tables 1 to 2 below.

[00165] FIG. 5 shows current-time graphs (left) and Nyquist plots (right) under 10 mV polarization of lithium metal batteries (Li||Li symmetric cells) prepared in (a, b) Comparative Example 1 (Control 1), (c, d) Example 2 (Control 2), and (e, f) Example 1 (WCCE) of the present invention.

[00166] [Table 1]

	Control 1	Control 2	WCCE
t_{Li^+}	0.55	0.57	0.88
σ (mS cm ⁻¹)	1.56	2.46	1.73
σ_{Li^+} (mS cm ⁻¹)	0.86	1.40	1.52

[00167]

[00168] [Table 2]

	Applied voltage	I_0	I_s	R_0	R_s	t_{Li^+}
	(mV)	(μ A)	(μ A)	(Ω)	(Ω)	
Control 1	10	19.16	16.00	406.2	415.3	0.55
Control 2	10	56.69	51.54	151.20	150.00	0.57
WCCE	10	45.33	42.45	70.08	65.60	0.88

[00169]

[00170] As shown in FIGS. 4 and 5 and Tables 1 to 2, lithium ion de-coordination was promoted in Example 1 (WCCE) and Example 2 (Control 2), resulting in improved lithium ion conductivity compared to Comparative Example 1 (Control 1).

[00171] Room Temperature Charge Transfer Resistance

[00172] The room temperature charge transfer resistance of lithium metal batteries prepared in Example 1 and Comparative Examples 1 to 2 was measured, and the results are shown in FIG. 6 and Table 3 below.

[00173] FIG. 6 shows Nyquist plots of lithium metal batteries prepared in Example 1 (WCCE), Example 2 (Control 2), and Comparative Example 1 (Control 1) of the present invention.

[00174] [Table 3]

	Control 1	Control 2	WCCE
$R_{ct} (\Omega \text{ cm}^2)$	589	221	126

[00175]

[00176] As shown in FIG. 6 and Table 3, lithium ion de-coordination is promoted in lithium metal batteries prepared in the examples compared to the comparative example, resulting in reduced charge transfer resistance at the lithium metal anode surface. Among them, it can be seen that the charge transfer resistance reduction effect of Example 1 is superior.

[00177] Although the embodiments of the present invention have been described above, those skilled in the art will appreciate that various modifications and changes can be made to the present invention without departing from the spirit of the invention as defined in the claims, including addition, modification, deletion, or supplementation of components, and such modifications and changes are also encompassed within the scope of the present invention.

WHAT IS CLAIMED IS:

1. A composition for preparing a polymer electrolyte, comprising:
a cationic monomer;
a multifunctional monomer;
a plastic crystal; and
a lithium salt.
2. The composition for preparing a polymer electrolyte according to claim 1, wherein the cationic monomer comprises at least one selected from the group consisting of imidazolium, pyridinium, phosphonium, sulfonium, pyrrolidinium, guanidinium, ammonium, isouronium, thiouronium, piperidinium, pyrazolium, methylium, and morpholinium.
3. The composition for preparing a polymer electrolyte according to claim 1, wherein the cationic monomer comprises a cationic functional group; and an anionic functional group.
4. The composition for preparing a polymer electrolyte according to claim 3, wherein the anionic functional group is an imide compound functional group.
5. The composition for preparing a polymer electrolyte according to claim 1, wherein the multifunctional monomer comprises at least one selected from the group consisting of

trimethylolpropane propoxylate triacrylate (TPPTA), ethoxylated trimethylolpropane triacrylate (ETPTA), trimethylolpropane triacrylate (TMPTA), and poly(ethylene glycol) diacrylate (PEGDA).

6. The composition for preparing a polymer electrolyte according to claim 1, wherein the molar ratio of the cationic monomer to the multifunctional monomer is from 70 to 90 : 30 to 10.

7. The composition for preparing a polymer electrolyte according to claim 1, wherein the plastic crystal is at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile.

8. The composition for preparing a polymer electrolyte according to claim 1, wherein the content of the plastic crystal is from 58 to 83 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

9. The composition for preparing a polymer electrolyte according to claim 1, wherein the lithium salt comprises at least one selected from the group consisting of lithium bis(trifluoromethanesulfonyl)imide (LiTFSI), lithium bis(pentafluoroethanesulfonyl)imide (LiBETI), and lithium bis(fluorosulfonyl)imide (LiFSI).

10. The composition for preparing a polymer electrolyte according to claim 1, wherein the content of the lithium salt is from 35 to 65 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

11. The composition for preparing a polymer electrolyte according to claim 1, further comprising at least one additive selected from the group consisting of vinylene carbonate and fluoroethylene carbonate (FEC).

12. The composition for preparing a polymer electrolyte according to claim 11, wherein the content of the additive is from 1 to 10 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer.

13. The composition for preparing a polymer electrolyte according to claim 1, further comprising an initiator.

14. A polymer electrolyte prepared using the composition for preparing a polymer electrolyte according to claim 1.

15. A lithium metal battery comprising the polymer electrolyte according to claim 14.

16. An apparatus comprising the lithium metal battery according to claim 15, wherein the apparatus is any one selected from the group consisting of a communication device, a transportation device, and an energy storage device.

17. A method for preparing a polymer electrolyte, comprising:

(A) mixing a cationic monomer, a multifunctional monomer, a plastic crystal, and a lithium salt to obtain a composition for preparing a polymer electrolyte; and (B) polymerizing the

composition for preparing the polymer electrolyte to prepare the polymer electrolyte.

18. The method for preparing a polymer electrolyte according to claim 17, wherein the polymerization is performed at 58 to 95°C for 1 to 7 hours.

19. The method for preparing a polymer electrolyte according to claim 17, wherein:
the cationic monomer is 1-allyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (AMIM-TFSI);

the multifunctional monomer is trimethylolpropane propoxylate triacrylate (TPPTA);

the molar ratio of the cationic monomer to the multifunctional monomer is from 68 to 82 : 32 to 18;

the plastic crystal is at least one selected from the group consisting of succinonitrile (butanedinitrile, $C_2H_4(CN)_2$), glutaronitrile, and adiponitrile;

the content of the plastic crystal is from 65 to 75 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer;

the content of the lithium salt is from 45 to 55 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer;

the composition for preparing the polymer electrolyte further comprises fluoroethylene carbonate (FEC), and the content of fluoroethylene carbonate (FEC) is from 2 to 7 parts by weight based on 100 parts by weight of the total of the cationic monomer and the multifunctional monomer;
and

the polymerization is performed at 65 to 78°C for 2.5 to 4 hours.

ABSTRACT

The present invention relates to a cationic polymer electrolyte and a method for preparing the same, wherein the polymer electrolyte of the present invention exhibits excellent ion transport properties.



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Title of Invention

CATIONIC POLYMER ELECTROLYTES AND PREPARATION METHOD OF THE SAME

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4011	BASIC FILING FEE- UTILITY	70.00	1	70.00
2111	UTILITY PATENT APPL. SEARCH FEE	308.00	1	308.00
2311	EXAMINATION OF ORIGINAL PATENT APPLICATION	352.00	1	352.00
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