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Filed on behalf of: Zhuhai CosMX Battery Co., Ltd.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZHUHAI COSMX BATTERY CO., LTD.

Petitioner

v.

NINGDE AMPEREX TECHNOLOGY LTD.,

Patent Owner

Case No. IPR2023-00586

Patent No. 10,833,363

DECLARATION OF DR. MENAHEM ANDERMAN

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I. INTRODUCTION

1. My name is Menahem Anderman, and I have been retained by counsel for Petitioner Zhuhai CosMX Battery Co., Ltd. (“CosMX” or “Petitioner”) as an expert witness to provide assistance regarding U.S. Patent No. 10,833,363 (“the ’363 patent”). Specifically, I have been asked to consider the validity of claims 1-16 of the ’363 patent (the “challenged claims”) in view of prior art, anticipation and obviousness considerations, and the understanding of a person of ordinary skill in the art at the time of the invention (“POSA”) as it relates to the ’363 patent. I have personal knowledge of the facts and opinions set forth in this declaration and believe them to be true. If called upon to do so, I would testify competently thereto.

2. I am being compensated for my time at my standard consulting rate. I am also being reimbursed for expenses that I incur during the course of this work. My compensation is not contingent upon the results of my study, the substance of my opinions, or the outcome of any proceeding involving the challenged claims. I have no financial interest in the outcome of this matter or in the pending litigation between Petitioner and Patent Owner.

3. My analysis here is based on my years of education, research, and experience, as well as my investigation and study of relevant materials, including those cited herein.

4. I may rely upon these materials, my knowledge and experience, and/or additional materials to rebut arguments raised by the Patent Owner. Further, I may also consider additional documents and information in forming any necessary opinions, including documents that may not yet have been provided to me.

5. My analysis of the materials in this proceeding is ongoing and I will continue to review any new material as it is provided. This declaration represents only those opinions I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information and on my continuing analysis of the materials already provided.

II. BACKGROUND AND QUALIFICATIONS

6. I am an expert in the field of electrochemical energy storage devices, including lithium-ion batteries. I believe that I am well qualified to serve as a technical expert in this matter based upon my qualifications, discussed in detail below. A detailed summary of my background and professional experience is set forth in my curriculum vitae, which is attached as **Appendix A**.

7. Based on my education and work experience, I am knowledgeable about the subject matter of the '363 patent and the related prior art. Specifically, my qualifications as an expert in the field of electrochemical energy storage devices stem from my over thirty-eight years of work experience in the field, as well as my education in chemistry.

8. I received a Bachelor of Science degree in Chemistry from Hebrew University in Jerusalem, Israel, in 1978, and a Ph.D. in Physical Chemistry from the University of California, Santa Barbara, in 1983.

9. Since 1983, I have been involved in the research, development, and manufacturing of batteries and related technologies and applications in the battery industry.

10. In 1996, I founded Total Battery Consulting, Inc., a private firm that offers consulting to the battery and associated industries and specializes in new cell development, technology, cost and market assessments, energy-storage-system evaluations, and energy-storage investments. I am currently the President of Total Battery Consulting, Inc. In this capacity, I have acquired a deep familiarity with the demands and capabilities of material developers, battery producers, and automotive-battery users in North America, Europe, and Asia.

11. In the past 20 years, I have published fourteen multi-client studies (“Industry Reports”) on the technology and markets of high-power energy-storage devices. These Industry Reports assess technology and market trends in energy storage for electrified vehicles based upon meetings with the major international automakers. Over 250 companies purchased one or more of these reports.

12. Between 2001 and 2015, I organized, and from 2001 to 2021, I have chaired, an annual conference with international attendees (the Advanced

Automotive Battery Conference, or AABC, *see* <http://www.advancedautobat.com>) on advanced automotive battery technology and market. I am the main creator of the technical program for these conferences. Participation in these conferences exceeds 800 companies and is growing rapidly.

13. From 1997 to 1999, I served as Vice President of Technology at Polystor Corporation, a Northern California firm that, at the time, developed and produced lithium-ion batteries. In my capacity as Vice President, I was responsible for all technical areas, including the research and development of lithium-ion battery electrolytes, cathode active materials, and battery casings, and oversaw a group of 45 scientists, engineers, and technicians dedicated to this research and development. I was also responsible for all Polystor intellectual property activity, including patent filings. Under my supervision, Polystor developed the 18650 cell, which achieved the then-highest energy density in the lithium-ion battery industry in addition to passing the commonly required International Electrotechnical Commission device safety tests and the UL safety and technical performance tests. The success of the 18650 cell enabled PolyStor to become the first American company to ship lithium-ion cells in volume.

14. From 1988 to 1996, I worked for Acme Electric Corporation as Vice President and General Manager of the Aerospace Division and as Technical Director of the Advanced Energy System Division. At Acme, I had overall technical

responsibility for the design, development, and transfer to production of a new line of sealed nickel-cadmium cells, which featured the highest specific power and cycle life in the aviation industry. I also co-invented and directed the development of a sealed nickel-cadmium battery incorporating flooded cells.

15. From 1983 to 1988, I worked for W.R. Grace & Co. as a Project and Group Leader of the Rechargeable Lithium Battery Group and as a Research Chemist. In my capacity as a Project and Group Leader, I shared responsibility for a business plan that assessed W.R. Grace's options to commercialize its rechargeable lithium battery technology, which exceeded the then state-of-the-art performance for rechargeable consumer batteries.

16. Throughout my career, I have written various articles on battery technology and application and given presentations on these topics at numerous conferences and in front of various government agencies and committees. I hold six issued U.S. patents related to energy-storage technology, which are also listed in my curriculum vitae.

17. Over the past 20 years, I have submitted expert reports, been deposed, and/or testified as an expert in numerous matters. I understand that those other proceedings are separate from this *inter partes* review proceeding.

III. SUMMARY OF OPINIONS

18. In my opinion, for the reasons described below, Hong discloses electrolytes, electrochemical devices, and electronic devices that anticipate claims 1-6, 11, 13, and 16 of the '363 patent.

19. It is my further opinion, for the reasons below, that claims 7-9 are obvious over the combination of Hong and Zhuang.

20. It is my further opinion, for the reasons below, that claim 10 is obvious over the combination of Hong and Kim '685.

21. It is my further opinion, for the reasons below, that claim 12 is obvious over the combination of Hong and Kim '934.

22. It is my further opinion, for the reasons below, that claims 14-15 are obvious over the combination of Fujikawa and Hong.

23. It is my further opinion, for the reasons below, that claim 16 is obvious over Hong.

IV. LEVEL OF ORDINARY SKILL IN THE ART

24. In rendering the opinions set forth in this declaration, I was asked to consider the patent claims and the prior art through the eyes of a person of ordinary skill in the art ("POSA") at the time of the alleged invention, which I understand is asserted to be as early as September 21, 2018. I understand that determining the ordinary skill in the art includes looking, among other considerations, at (i) the type

of problems encountered in the art; (ii) prior art solutions to those problems; (iii) rapidity with which innovations are made; (iv) sophistication of the technology; and (v) educational level of active workers in the field. I understand that a POSA is not a specific real individual, but rather is a hypothetical individual having the qualities reflected by the factors above. I understand that a POSA would also have knowledge from the teachings of the prior art, including the art cited below.

25. Taking these factors into consideration, on or before September 21, 2018, in my opinion, a person of ordinary skill in the art of the '363 patent would have had a Ph.D. or a similar advanced degree in chemistry, chemical engineering, materials science, or a related field, and two or more years of experience related to the design, research, evaluation, preparation, and/or manufacture of electrochemical energy storage devices. This level of skill is approximate, and more experience would compensate for less formal education, and vice versa. I note that the '363 patent defines the field of its invention: "Field of the Invention The present disclosure relates to the technical field of energy storage technologies, in particular to an electrolyte and an electrochemical device containing the electrolyte." Ex. 1001, 1:10-15. Before September 21, 2018, my level of skill in the art was at least that of a person of ordinary skill in the art. I am qualified to provide opinions concerning what a POSA would have known and understood at that time, and my analysis and conclusions herein are from the perspective of a POSA as of that date.

V. MATERIALS CONSIDERED AND RELIED UPON

26. In reaching the conclusions described in this declaration, I have relied on the documents and materials cited herein as well as those identified in this declaration, including the '363 patent, the prosecution history of the '363 patent, and prior art references cited herein. These materials comprise patents, related documents, and printed publications. Each of these materials is a type of document that experts in my field would have reasonably relied upon when forming their opinions.

27. I have also relied on my education, training, research, knowledge, and personal and professional experience in the relevant technologies and systems that were already in use prior to, and within the timeframe of the earliest asserted invention date of the claimed subject matter in the '363 patent, which is September 21, 2018.

- Ex. 1001:** U.S. Patent No. 10,833,363 ("the '363 patent")
- Ex. 1002:** Prosecution History of U.S. Patent No. 10,833,363
- Ex. 1004:** Chinese Patent No. 106848381 to Hong et al. ("Hong")
- Ex. 1005:** Translation of Chinese Patent No. 106848381 to Hong et al. ("Hong")
- Ex. 1006:** U.S. Patent App. Pub. No. 2017/0084956 to Zhuang et al. ("Zhuang")
- Ex. 1007:** U.S. Patent No. 6,544,685 to Kim et al. ("Kim '685")
- Ex. 1008:** U.S. Patent App. Pub. No. 2017/0069934 to Kim et al. ("Kim '934")
- Ex. 1009:** U.S. Patent App. Pub. No. 2007/0172736 to Fujikawa et al. ("Fujikawa")
- Ex. 1010:** Material Safety Data Sheet for Adiponitrile (ADN)

- Ex. 1011:** Material Safety Data Sheet for Diethyl Carbonate (DEC)
- Ex. 1012:** Material Safety Data Sheet for Ethylene Glycol Bis(propionitrile) Ether (DENE)
- Ex. 1013:** Material Safety Data Sheet for Ethylene Sulfate (DTD)
- Ex. 1014:** Material Safety Data Sheet for Ethylene Carbonate (EC)
- Ex. 1015:** Material Safety Data Sheet for Fluoroethylene Carbonate (FEC)
- Ex. 1016:** Material Safety Data Sheet for 1,3,6-Hexane Tricarbonitrile (HTCN)
- Ex. 1017:** Material Safety Data Sheet for Lithium Hexafluorophosphate (LiPF₆)
- Ex. 1018:** Material Safety Data Sheet for Lithium bis(trifluoromethanesulfonyl)imide (LiTFSI)
- Ex. 1019:** Material Safety Data Sheet for Propylene Carbonate (PC)
- Ex. 1020:** Material Safety Data Sheet for Propyl Propionate (PP)
- Ex. 1021:** Material Safety Data Sheet for 1,3-Propane Sultone (PS)
- Ex. 1022:** Material Safety Data Sheet for Succinonitrile (SN)
- Ex. 1023:** Material Safety Data Sheet for Propanephosphonic Acid Anhydride (T3P)
- Ex. 1024:** Material Safety Data Sheet for Vinylethylene Carbonate (VEC)
- Ex. 1025:** Seward, et al., “The Dielectric Constants of Ethylene Carbonate and of Solutions of Ethylene Carbonate in Water, Methanol, Benzene and Propylene Carbonate,” *J. Phys. Chem.*, 62:1, 127-128 (1958)
- Ex. 1026:** Declaration of Kelley M. Hayes Greenhill dated February 23, 2023
- Ex. 1027:** Table of Properties for Common Solvents Used in Organic Chemistry (ACS Division of Organic Chemistry)
- Ex. 1028:** ATL’s Infringement Contentions regarding the ’363 patent filed in *Ningde Amperex Tech. Ltd. v. Zhuhai CosMX Battery Co., Ltd.*, Civ. No. 2:22-cv-00232-JRG (E.D. Tex.)

VI. LEGAL PRINCIPLES

28. I am not a lawyer. My understanding of the legal standards to apply in reaching the conclusions in this declaration is based on discussions with counsel for Petitioner and my reading of the documents submitted in this proceeding. In

preparing this declaration, I have tried to faithfully apply these legal standards to the challenged claims.

A. Claim Construction

29. I have been instructed that the terms appearing in the '363 patent should be interpreted in view of the claim language itself, the specification, the prosecution history of the patent, and any relevant extrinsic evidence. The words of a claim are generally given their ordinary and customary meaning, which is the meaning that the term would have to a person of ordinary skill in the art at the time of the invention, which I have assumed here is September 21, 2018. While claim limitations cannot be read in from the specification, the specification is the single best guide to the meaning of a disputed term. I have followed these principles in reviewing the claims of the '363 patent and forming the opinions set forth in this declaration.

B. Anticipation

30. I have been told that under 35 U.S.C. § 102, a patent claim is invalid if its subject matter was patented or described in a printed publication before the effective filing date of the claimed invention. I have been told that this is referred to as invalidity by anticipation. I have been told that a patent claim is anticipated under § 102 if a single prior art reference discloses all limitations of the claimed invention.

C. Obviousness

31. I understand that the existence of each and every element of the claimed invention in a prior art does not necessarily prove obviousness and that most, if not all, inventions rely on building blocks of prior art. I have been told that under 35 U.S.C. § 103, a patent claim may be obvious if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person of ordinary skill in the art to which said subject matter pertains. I have been told that a proper obviousness analysis requires the following:

- a. Determine the scope and content of the prior art;
- b. Ascertain the differences between the prior art and the claims at issue;
- c. Resolve the level of ordinary skill in the pertinent art; and
- d. Consider evidence of secondary indicia of non-obviousness (if available).

32. I have been told that the relevant time for considering whether a claim would have been obvious to a person of ordinary in the art is the time of invention. For my obviousness analysis, counsel for Petitioner instructed me to assume that the date of invention for the challenged claims is September 21, 2018, the filing date of the patent application to which the '363 patent claims priority. My opinions would not change if I assumed a later date of invention.

33. I have been told that a reference may be modified or combined with other references, or with a person of ordinary skill in the art's own knowledge, if the person would have found the modification or combination obvious. I have also been told that a person of ordinary skill in the art is presumed to know all the relevant prior art, and the obviousness analysis may take into account the inferences and creative steps that a person of ordinary skill in the art would employ.

34. I have been told that whether a prior art reference renders a patent claim obvious is determined from the perspective of a person of ordinary skill in the art. I have also been told that, while there is no requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed invention, and while a suggestion to combine known elements to achieve the claimed invention may come from the prior art as a whole or individually and may consider the inferences and creative steps a person of ordinary skill in the art would employ, as filtered through the knowledge of one skilled in the art, obviousness grounds cannot be sustained by mere conclusory statements and must include some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.

35. I have been told that there is no rigid rule that a reference or combination of references must contain a "teaching, suggestion, or motivation" to combine references. However, I also have been told that the "teaching, suggestion,

or motivation” test can be used in establishing a rationale for combining elements of the prior art. I have also been told to be aware of distortions caused by hindsight bias, and that reading into the prior art the teachings of the invention at issue is improper.

VII. TECHNOLOGY BACKGROUND

A. Basic Principles of Lithium-Ion Batteries

36. Lithium-ion batteries have been commercially available since 1991 and have become a popular power source for small portable and other electronic devices because of their high energy density. *See* Ex. 1005, ¶2; Ex. 1009, ¶2.

37. A typical lithium-ion battery contains a positive electrode (cathode), a negative electrode (anode), a separator, and an electrolyte. The cathode typically comprises a current collector and a layered active material that in the discharged state contains lithium, while the anode typically comprises a current collector with a layered active material capable of receiving lithium ions. The separator prevents contact between the cathode and anode, which would otherwise cause a short circuit. The electrolyte serves as the medium through which lithium ions travel between the cathode and the anode, and comprises lithium salt, solvent, and optionally additives.

38. Lithium-ion batteries operate via a “rocking-chair” mechanism, so called because the lithium ions move or “rock” back and forth between the cathode and anode as the battery charges and discharges.

39. As shown in Figure 1 below, charging the battery dislodges lithium from the cathode in the form of lithium ions. Those lithium ions enter the electrolyte, forcing lithium ions already present in the electrolyte to move into the anode. The dislodging of the lithium ions from the cathode leaves free electrons in the cathode. Those free electrons cannot diffuse into the electrolyte but instead flow through an external circuit into the anode where they recombine with the lithium ions in the anode. This process creates an electrochemical potential between the anode and the cathode.

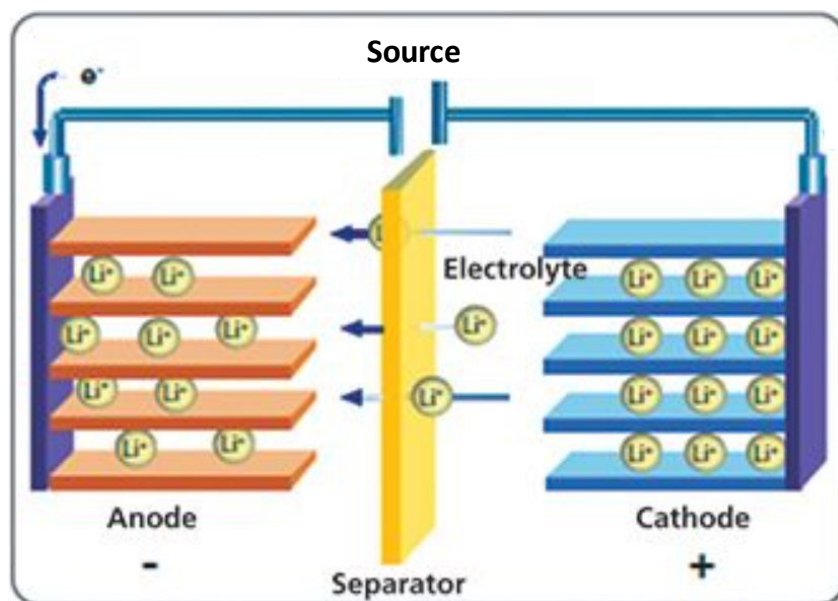


Figure 1: Charging Mechanism for a Lithium-Ion Battery

40. During discharge, the reverse electrochemical process occurs, as shown in Figure 2 below. When a load is connected between the anode and cathode, it creates a pathway for electrons to flow between the anode and the cathode. The difference in electrochemical potential drives electrons from the anode to the cathode

through the load, providing power to the load. The release of electrons from the anode also dislodges lithium ions from the anode into the electrolyte, which causes lithium ions in the electrolyte to enter the cathode, where they recombine with electrons from the anode.

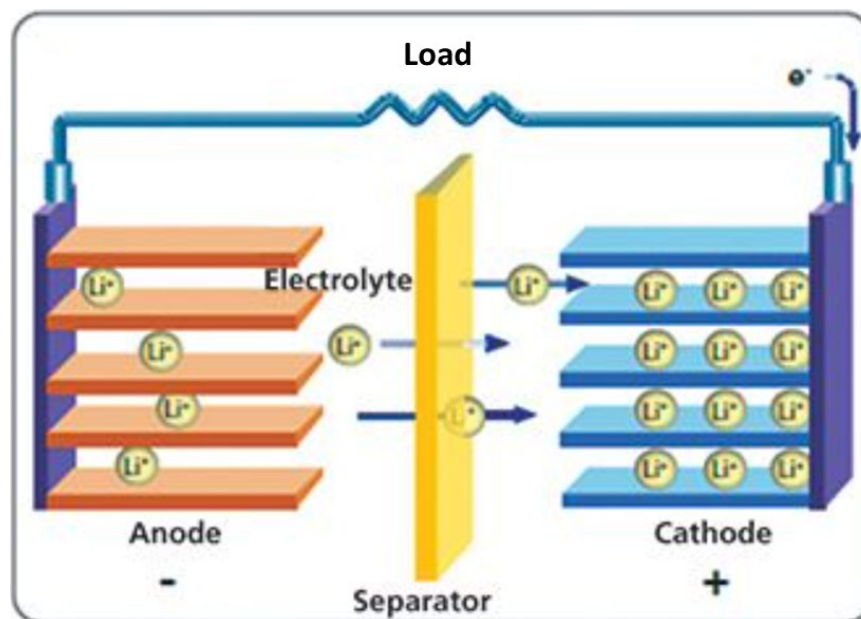


Figure 2: Discharge Mechanism for a Lithium-Ion Battery

41. One charge-discharge sequence is called a cycle. An animation showing a charge-discharge cycle is available here: <https://www.energy.gov/eere/articles/how-does-lithium-ion-battery-work>.

42. In contrast with primary batteries like alkaline batteries, which cannot be recharged because they irreversibly consume chemical energy in the cathode, lithium-ion batteries are secondary (rechargeable) batteries that can be cycled many times. The discharge reaction in lithium-ion batteries can be reversed by forcing a

lithium ion to reversibly return to the anode, thereby returning the battery to its composition and structure for additional cycles.

B. The Claimed Electrolytes Were Known to Improve the Stability of the SEI Layer

43. As the medium through which lithium ions travel between the cathode and the anode, the electrolyte must remain stable. *See supra*, § VII.A. One feature that helps maintain the electrolyte stability is the solid electrolyte interphase (“SEI”) layer. The SEI layer is a passivating layer formed on the electrode through partial decomposition of the electrolyte, predominantly during the first cycle, that inhibits further electrolyte decomposition during later cycles. It is electronically insulating but ionically conductive, at least for lithium ions, meaning that it allows lithium ions to pass through it but not electrons.

44. As the demand for higher energy density pushed manufacturers to increase the voltage of lithium-ion batteries, stability of the SEI layer became more important. *See, e.g.*, Ex. 1005, ¶2 (“[I]t is easy for the SEI film formed on the surface of a battery’s electrode to be damaged under a high voltage or a high temperature.”). As was known in the lithium-ion battery industry prior to the ’363 patent, the SEI layer became more stable with electrolytes comprising propyl propionate, a dinitrile compound, and a trinitrile compound. *See* Ex. 1005, ¶¶34-43.

VIII. OVERVIEW OF PRIOR ART

A. Hong

45. Chinese Patent No. 106848381 (“**Hong**”) (Exs. 1004/1005), published on June 13, 2017.

46. Hong is directed to electrolytes for rechargeable lithium batteries comprising a tricyanophosphite or tricyanophosphate functional compound. Ex. 1005, ¶¶5-9. Like the ’363 patent, Hong identifies high voltages as a concern for the stability of the SEI layer. Ex. 1005, ¶2 (“[I]t is easy for the SEI film formed on the surface of a battery’s electrode to be damaged under a high voltage or a high temperature.”). Also, like the ’363 patent, Hong recognizes the insufficiency of dinitrile compounds when used as the sole additive and explains that the trinitrile tricyanophosphite/tricyanophosphate compounds result in a stable SEI layer on the cathode, among other benefits. Ex. 1005, ¶¶2-4, 17-18. Hong discloses that the electrolyte may also contain the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶¶15, 35. Hong discloses exemplary embodiments of an electrolyte comprising propyl propionate as an organic solvent and dinitrile and trinitrile compounds as additives that achieve Hong’s stated objectives. *See* Ex. 1005, ¶¶34-43.

B. Zhuang

47. U.S. Patent App. Pub. No. 2017/0084956 (“**Zhuang**”) (Ex. 1006), published on March 23, 2017, from U.S. Application No. 15/014.365, filed February 3, 2016.

48. Zhuang is directed to electrolytes comprising a fluoroether compound, a carboxylate compound such as propyl propionate, and a dinitrile compound comprising an ether bond such as ethylene glycol bis(propionitrile) ether (DENE). Ex. 1006, ¶¶5, 10. Zhuang states that the recited electrolyte can improve lithium-ion battery high-temperature storage performance, high-temperature cycle life performance, and rate performance. Ex. 1006, ¶5.

C. Kim ’685

49. U.S. Patent No. 6,544,685 (“**Kim ’685**”) (Ex. 1007), issued on April 8, 2003, from U.S. Application No. 09/766,056, filed January 19, 2001.

50. Kim ’685 is directed to electrolytes comprising a non-aqueous organic solvent and an alkylphosphonic acid cyclic anhydride, which is a type of cyclic phosphonic anhydride. Ex. 1007, 3:26-42. Kim ’685 explains that the cyclic phosphonic anhydride mitigates carbonate solvent decomposition and reduces battery expansion. Ex. 1007, 3:14-25.

D. Kim '934

51. U.S. Patent App. Pub. No. 2017/0069934 (“**Kim '934**”) (Ex. 1008), published on March 9, 2017, from U.S. Application No. 15/177,628, filed June 9, 2016.

52. Kim '934 is directed to electrolytes comprising trinitrile compounds and cyclic carboxylate esters. Ex. 1008, ¶¶10-13. Kim '934 explains that the combination of the trinitrile compounds, such as 1,3,6-hexanetricarbonitrile (HTCN), and the cyclic carboxylate esters, such as γ -butyrolactone, synergistically improves the stability of the SEI layer on the cathode. Ex. 1008, ¶¶38-41.

E. Fujikawa

53. U.S. Patent App. Pub. No. 2007/0172736 (“**Fujikawa**”) (Ex. 1009), published on July 26, 2007, from U.S. Application No. 11/698,094, filed January 26, 2007.

54. Fujikawa is directed to improvements to lithium-ion battery structure. It discloses batteries comprising a heat-resistant layer between the cathode and the anode, including into batteries having a coating comprising a single-sided coating and a double-sided coating on both the cathode and the anode. Ex. 1009, ¶¶6, 19-20, 96-97. Fujikawa discloses that a coating comprising a single-sided coating and a double-sided coating can enable excellent high output characteristics. Ex. 1009, ¶116.

IX. THE '363 PATENT

55. The '363 patent, entitled "Electrolyte and Electrochemical Device," issued on November 10, 2020, from U.S. Application No. 16/211,853, filed December 6, 2018. It asserts priority to a Chinese application filed September 21, 2018. Counsel for Petitioner instructed me to assume that the priority date is September 21, 2018.

A. Specification

56. Like Hong, the '363 patent identifies electrolyte decomposition at high voltages as a concern, stating that "at high voltages, the oxidation activity of the positive electrode material increases, and the stability decreases, which makes the electrolyte decompose on the surface of the positive electrode easily or cause deterioration of the battery material, resulting in a decrease in battery capacity." Ex. 1001, 1:26-31. Like Hong, the '363 patent acknowledges that one known strategy for improving electrolyte stability involved incorporating a dinitrile compound to "form a protective film on the cathode of the electrochemical device, so as to inhibit the decomposition of the solvent in the electrochemical device." Ex. 1001, 1:43-46. However, an electrolyte comprising a dinitrile compound alone produced an unstable film. Ex. 1001, 1:46-49. Thus, the '363 patent purports to use "a mixture of a dinitrile compound, a trinitrile compound and propyl propionate [that forms] a firm

protective film which is not easily decomposed on the surface of the cathode at a high potential,” the same solution already taught by Hong. Ex. 1001, 1:49-54.

B. Claims

57. The '363 patent has three independent claims: claims 1, 13, and 16, which are directed to an electrolyte, an electrochemical device, and an electronic device, respectively.

58. Claim 1 recites:

An electrolyte, comprising a dinitrile compound, a trinitrile compound, and propyl propionate,

wherein, based on a total weight of the electrolyte, a weight percentage of the dinitrile compound is X and a weight percentage of the trinitrile compound is Y, where X and Y meet conditions represented by Formula (1) and Formula (2):

$\text{about } 2 \text{ wt } \% \leq (X+Y) \leq \text{about } 11 \text{ wt } \% \quad (1); \text{ and}$

$\text{about } 0.1 \leq (X/Y) \leq \text{about } 8 \quad (2),$

wherein, based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z, where Y and Z meet a condition represented by Formula (3):

$\text{about } 0.01 \leq (Y/Z) \leq \text{about } 0.3 \quad (3).$

59. Claim 13 recites:

An electrochemical device, wherein the electrochemical device comprises electrodes and an electrolyte comprising a dinitrile compound, a trinitrile compound, and propyl propionate,

wherein, based on the total weight of the electrolyte, the weight percentage of the dinitrile compound is X and the weight percentage of the trinitrile compound is Y, where X and Y meet the conditions represented by Formula (1) and Formula (2):

$$\text{about } 2 \text{ wt } \% \leq (X+Y) \leq \text{about } 11 \text{ wt } \% \quad (1); \text{ and}$$

$$\text{about } 0.1 \leq (X/Y) \leq \text{about } 8 \quad (2).$$

60. Claim 16 recites:

An electronic device, comprising an electrochemical device that includes electrodes and an electrolyte comprising a dinitrile compound, a trinitrile compound, and propyl propionate,

wherein, based on the total weight of the electrolyte, the weight percentage of the dinitrile compound is X and the weight percentage of the trinitrile compound is Y, where X and Y meet the conditions represented by Formula (1) and Formula (2):

$$\text{about } 2 \text{ wt } \% \leq (X+Y) \leq \text{about } 11 \text{ wt } \% \quad (1); \text{ and}$$

about $0.1 \leq (X/Y) \leq$ about 8 (2).

C. Summary of Relevant Prosecution History of the '363 Patent

61. The Examiner issued one prior art-based rejection during prosecution of the '363 patent, rejecting the claims as obvious over Ohashi as the primary reference. Ex. 1002, 815-821. In response, Applicant argued that Ohashi did not teach or suggest the claimed formulaic ranges and that “the results yielded by the claimed invention are unexpected in view of the cited prior art.” Ex. 1002, 859-861. The Examiner’s Notice of Allowance indicates acceptance of both arguments. Ex. 1002, 869-870.

X. CLAIM CONSTRUCTION

62. I have applied the above-mentioned legal standards of claim construction here. In preparing my opinions, I have construed the term “a weight percentage of the dinitrile compound is X” to mean “the total weight percentage of all dinitrile compounds in the electrolyte is X.” I have also construed the term “a weight percentage of the trinitrile compound is Y” to mean “the total weight percentage of all trinitrile compounds in the electrolyte is Y.” In my opinion, these constructions are consistent with the plain and ordinary meaning the terms would have to a person of ordinary skill in the art at the time of the invention. For example, the text of dependent claims 2-5 states that “the dinitrile compound” may be a combination of compounds and that “the trinitrile compound” may be a combination

of compounds. *See* Ex. 1001, claim 2 (“the dinitrile compound comprises a compound of Formula (4) or (5). . . *or a combination thereof*”) (emphasis added); claim 3 (“the dinitrile compound is one selected from the group consisting of. . . and *any combination thereof*”) (emphasis added); claim 4 (“the trinitrile compound comprises a compound of Formula (6) or (7). . . or a combination thereof”); claim 5 (“The electrolyte according to claim 1, wherein the trinitrile compound is one selected from the group consisting of. . . and *any combination thereof*.”) (emphasis added). These constructions are also consistent with the constructions implicitly adopted by ATL in its infringement contentions in the co-pending district court litigation. *See* Ex. 1028, 2 (calculating “X” based on the sum of two dinitrile components).

XI. STATEMENT OF OPINIONS AND THEIR BASES

63. As stated above, I have been asked to determine whether claims 1-16 of the ’363 patent are anticipated by the prior art or would have been obvious in view of the prior art. For the reasons below, in my opinion, claims 1-6, 11, 13, and 16 are anticipated by the prior art, and claims 7-10, 12, and 14-16 would have been obvious in view of the prior art.

A. Hong Anticipates Claims 1-6, 11, 13, and 16 of the ’363 Patent

64. In my opinion, for the reasons discussed below, Hong anticipates claims 1-6, 11, 13, and 16 of the ’363 patent.

1. Claim 1

65. In my opinion, Hong anticipates claim 1. In particular, at least Embodiments 2-15, 18, 20-21, 25, and Comparison Case 6 of Hong anticipate claim 1. For the purposes of my analysis below, I highlight Embodiments 2, 18, 25, and Comparison Case 6 as representative examples. I chose these embodiments because they demonstrate that Hong discloses anticipatory embodiments that collectively span almost the entirety of each range recited in Formulas (1)-(3).

66. I have replicated below the table that Hong provides in paragraphs 34-35. *See* Table 1. “[P]ercentage refers to the mass percentage in the final electrolyte, and concentration refers to the concentration in the final electrolyte.” Ex. 1005, ¶38. I have highlighted the dinitrile compounds in blue, the trinitrile compounds in green, and the propyl propionate component in red.

	Organic solvent (wt ratio)	Additive (wt %)	Functional compound (wt %)	Electrolyte substance
Embodiment 2	EC:PP:DEC:PC = 25:25:40:10	3% PS, 5% FEC, 2% ADN, 1% SN, 0.3% VEC, 1% DENE	0.8% Compound I ₁	1.1 M LiPF ₆
Embodiment 18	EC:PP:DEC:PC = 25:25:40:10	3% PS, 5% FEC, 2% ADN, 1% SN, 0.3% VEC, 1% DENE	5% Compound I ₁	1.1 M LiPF ₆
Embodiment 25	EC:PP:DEC:PC = 25:25:40:10	3% PS, 5% FEC, 2% ADN, 1% SN, 0.5% DTD,	1.5% Compound II ₆	1.0 M LiPF ₆ +0.5 M LiTFSI

		1% DENE, 0.5% HTCN		
Comparison Case 6	EC:PP:DEC:PC = 25:25:40:10	3% PS, 5% FEC, 2% ADN, 1% SN, 0.5% DTD, 1% DENE, 0.5% HTCN	--	1.0 M LiPF ₆ +0.5 M LiTFSI

Table 1: Composition of Certain Anticipatory Embodiments in Hong

a. [1pre]: “An electrolyte, comprising”

67. In my opinion, Hong discloses electrolytes. In particular, Hong states that “[t]he purpose of the present invention is achieved through the following technical solution: an electrolyte. . .” Ex. 1005, ¶¶6-7. Hong discloses example embodiments of an electrolyte in Embodiments 2, 18, 25, and Comparison Case 6. Ex. 1005, ¶¶34-35.

b. [1.a]: “a dinitrile compound”

68. In my opinion, Hong discloses electrolytes comprising a dinitrile compound. I note that the ’363 patent describes a “dinitrile compound” as “a compound comprising two cyano groups.” Ex. 1001, 1:39-41. Hong discloses that the electrolyte may comprise one or more of the dinitrile compounds succinonitrile (SN), adiponitrile (ADN), and ethylene glycol bis(propionitrile) ether (DENE), each of which comprises two cyano groups. Ex. 1005, ¶15. Hong’s Embodiments 2, 18, 25, and Comparison Case 6 contain the dinitrile compounds succinonitrile (SN),

adiponitrile (ADN), and ethylene glycol bis(propionitrile) ether (DENE), each of which comprises two cyano groups. Ex. 1005, ¶¶34-35.

c. [1.b]: “a trinitrile compound, and”

69. In my opinion, Hong discloses electrolytes further comprising a trinitrile compound. I note that the '363 patent describes a “trinitrile compound” as “a compound comprising three cyano groups.” Ex. 1001, 1:41-42.

70. Hong discloses tricyanophosphite and tricyanophosphate “functional” compounds as electrolyte additives. *See* Ex. 1005, ¶¶7-9, 19-24. Each tricyanophosphite and tricyanophosphate is a trinitrile compound comprising three cyano groups. I have highlighted the cyano groups in the tricyanophosphite and tricyanophosphate compounds below.

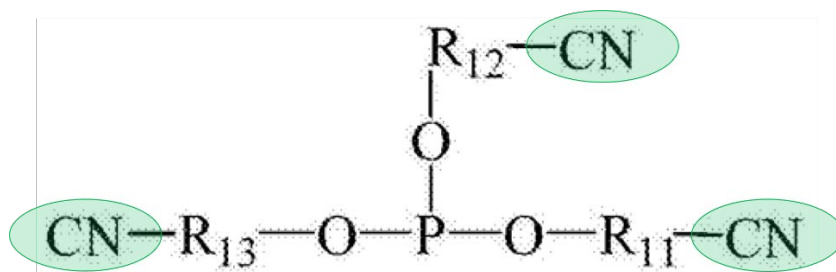


Figure 3: General Structure of Hong’s Tricyanophosphite Compounds

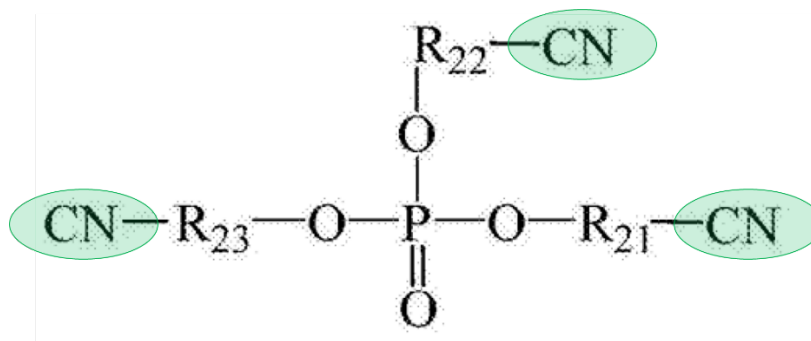


Figure 4: General Structure of Hong's Tricyanophosphate Compounds

71. Hong also discloses that the electrolyte may further comprise the trinitrile compound 1,3,6-hexane tricarbonitrile (HTCN). *See* Ex. 1005, ¶15 (“The additive is a common additive used in the art, for example, the additive is. . . 1,3,6-hexane tricarbonitrile (HTCN). . . .”); *see also* ¶¶34-35.

72. Embodiments 2, 18, and 20 contain the tricyanophosphite Compound I₁. Ex. 1005, ¶¶34-35. I have highlighted the cyano groups present in Compound I₁ in Figure 5 below.

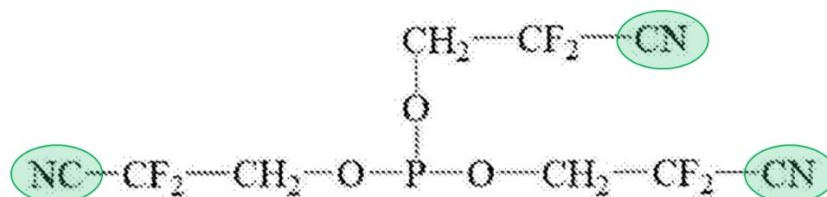


Figure 5: Structure of Compound I₁ in Hong's Embodiments 2, 18, and 20

73. Embodiments 3 and 21 contain the tricyanophosphite Compound I₂. Ex. 1005, ¶¶34-35. I have highlighted the cyano groups present in Compound I₂ in Figure 6 below.

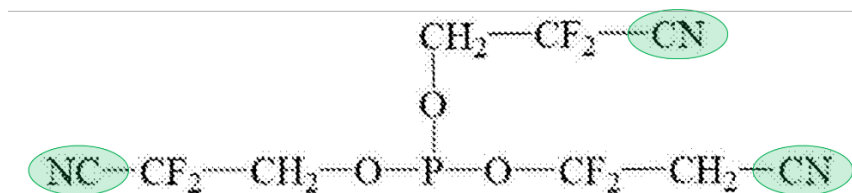


Figure 6: Structure of Compound I₂ in Hong's Embodiments 3 and 21

74. Embodiment 4 contains the tricyanophosphite Compound I₃. Ex. 1005,

¶35. I have highlighted the cyano groups present in Compound I₃ in Figure 7 below.

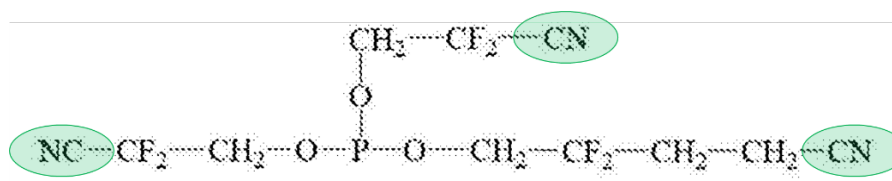


Figure 7: Structure of Compound I₃ in Hong's Embodiment 4

75. Embodiment 5 contains the tricyanophosphite Compound I₄. Ex. 1005,

¶35. I have highlighted the cyano groups present in Compound I₄ in Figure 8 below.

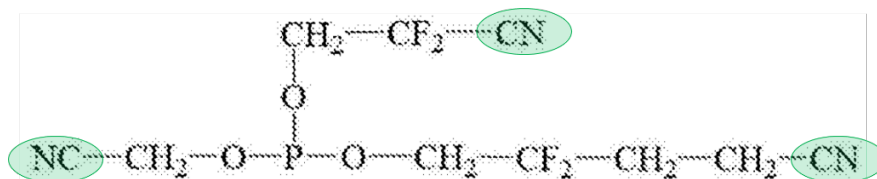


Figure 8: Structure of Compound I₄ in Hong's Embodiment 5

76. Embodiment 6 contains the tricyanophosphite Compound I₅. Ex. 1005,

¶35. I have highlighted the cyano groups present in Compound I₅ in Figure 9 below.

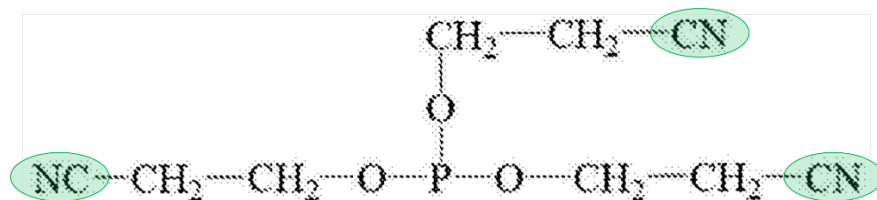


Figure 9: Structure of Compound I₅ in Hong's Embodiment 6

77. Embodiment 7 contains the tricyanophosphite Compound I₆. Ex. 1005,

¶35. I have highlighted the cyano groups present in Compound I₆ in Figure 10 below.

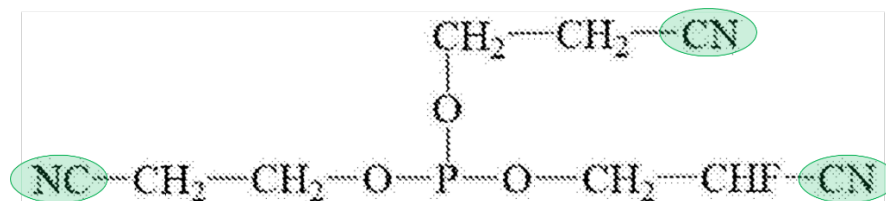


Figure 10: Structure of Compound I₆ in Hong's Embodiment 7

78. Embodiment 8 contains the tricyanophosphite Compound I₇. Ex. 1005,

¶35. I have highlighted the cyano groups present in Compound I₇ in Figure 11 below.

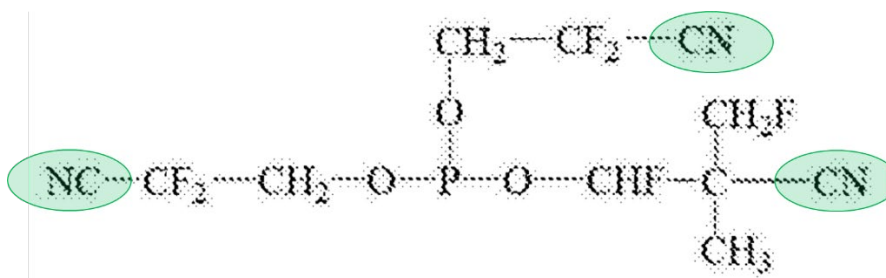


Figure 11: Structure of Compound I₇ in Hong's Embodiment 8

79. Embodiment 9 contains the tricyanophosphite Compound II₁. Ex. 1005,

¶35. I have highlighted the cyano groups present in Compound II₁ in Figure 12 below.

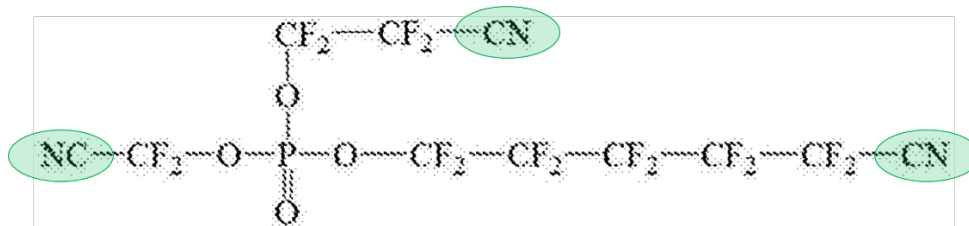


Figure 12: Structure of Compound II₁ in Hong's Embodiment 9

80. Embodiments 10 and 20 contain the tricyanophosphite Compound II₂.
Ex. 1005, ¶35. I have highlighted the cyano groups present in Compound II₂ in Figure 13 below.

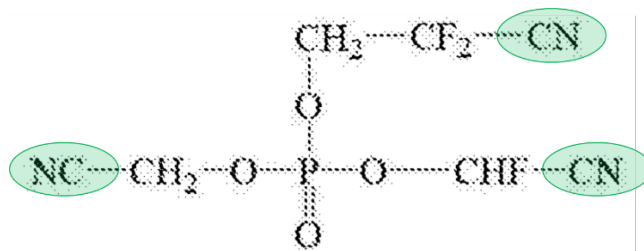


Figure 13: Structure of Compound II₂ in Hong's Embodiments 10 and 20

81. Embodiment 11 contains the tricyanophosphite Compound II₃. Ex. 1005, ¶35. I have highlighted the cyano groups present in Compound II₃ in Figure 14 below.

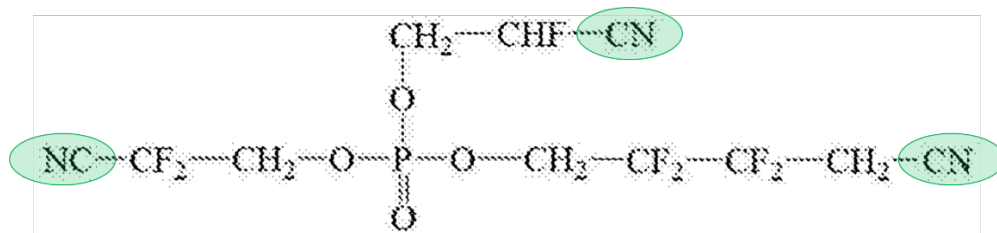


Figure 14: Structure of Compound II₃ in Hong's Embodiment 11

82. Embodiment 12 contains the tricyanophosphite Compound II₄. Ex. 1005, ¶35. I have highlighted the cyano groups present in Compound II₄ in Figure 15 below.

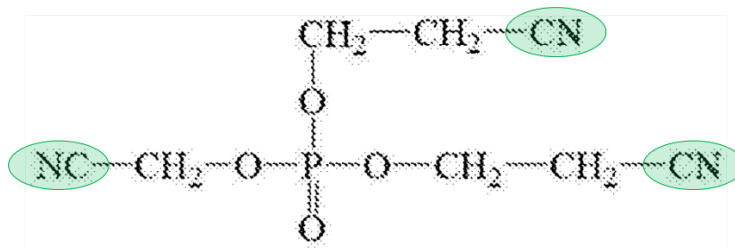


Figure 15: Structure of Compound II₄ in Hong's Embodiment 12

83. Embodiments 13 and 21 contain the tricyanophosphite Compound II₅.
Ex. 1005, ¶35. I have highlighted the cyano groups present in Compound II₅ in Figure 16 below.

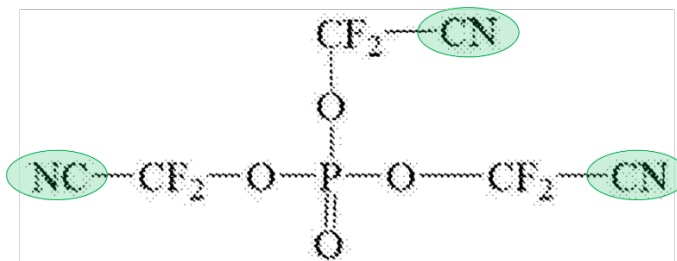


Figure 16: Structure of Compound II₅ in Hong's Embodiments 13 and 21

84. Embodiments 14 and 25 contains the tricyanophosphate Compound II₆.
Ex. 1005, ¶35. Embodiment 25 also contains the trinitrile compound 1,3,6-hexane tricarbonitrile (HTCN). Ex. 1005, ¶35. I have highlighted the cyano groups present in Compound II₆ in Figure 17 below.

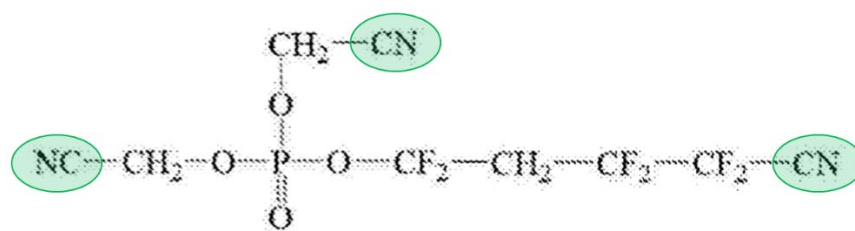


Figure 17: Structure of Compound II₆ in Hong's Embodiments 14 and 25

85. Embodiment 15 contains the tricyanophosphite Compound II₇. Ex. 1005, ¶35. I have highlighted the cyano groups present in Compound II₇ in Figure 18 below.

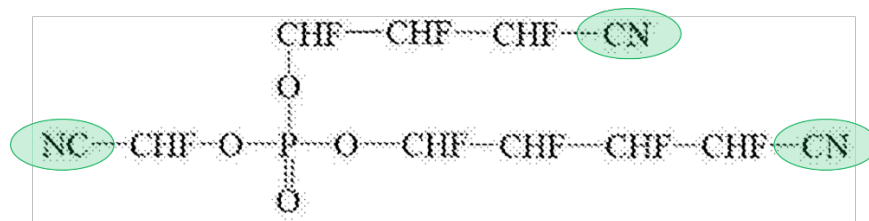


Figure 18: Structure of the Compound II₇ in Hong's Embodiment 15

86. Embodiment 25 and Comparison Case 6 contain the trinitrile compound 1,3,6-hexane tricarbonitrile (HTCN). Ex. 1005, ¶35.

d. [1.c]: “propyl propionate,”

87. In my opinion, Hong discloses electrolytes that further comprise propyl propionate. Hong discloses that the organic solvent may include propyl propionate and recites it among a list of preferred solvent components. Ex. 1005, ¶¶13-14. Embodiments 2, 18, 25, and Comparison Case 6 of Hong contain propyl propionate (PP) as a co-solvent in the electrolyte. Ex. 1005, ¶¶34-35.

e. [1.d]: “wherein, based on a total weight of the electrolyte, a weight percentage of the dinitrile

compound is X and a weight percentage of the trinitrile compound is Y, where X and Y meet conditions represented by Formula (1). . . about 2 wt % $\leq (X+Y) \leq$ about 11 wt % (1);”

88. In my opinion, Hong discloses electrolytes satisfying Formula (1).

89. Embodiments 2, 18, 25, and Comparison Case 6 contain 2 wt % of the dinitrile compound adiponitrile (ADN), 1 wt % of the dinitrile compound succinonitrile (SN), and 1 wt % of the dinitrile compound ethylene glycol bis(propionitrile) ether (DENE). Ex. 1005, ¶¶34-35. The total weight percentage of the dinitrile compounds for those examples is 4 wt % (i.e., $X = 4$ wt %).

90. Embodiment 2 contains 0.8 wt % of the trinitrile Compound I₁. Ex. 1005, ¶34. Thus, for Embodiment 2, $Y = 0.8$ wt %.

91. Embodiment 18 contains 5 wt % of the trinitrile Compound I₁. Ex. 1005, ¶35. Thus, for Embodiment 18, $Y = 5$ wt %.

92. Embodiment 25 contains 1.5 wt % of the trinitrile Compound II₆ and 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. The total weight percentage of the dinitrile compounds for Embodiment 25 is 2.0 wt % (i.e., $Y = 2.0$ wt %).

93. Comparison Case 6 contains 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. Thus, for Comparison Case 6, $Y = 0.5$ wt %.

94. In my opinion, Hong discloses electrolytes satisfying Formula (1). Embodiment 2 discloses an electrolyte wherein $X+Y = 4 + 0.8 = 4.8$ wt %. Embodiment 18 discloses an electrolyte wherein $X+Y = 4 + 5 = 9$ wt %. Embodiment 25 discloses an electrolyte wherein $X+Y = 4 + 2.0 = 6.0$ wt %. Comparison Case 6 discloses an electrolyte wherein $X+Y = 4 + 0.5 = 4.5$ wt %.

95. Table 2 below summarizes the weight proportion of dinitrile compounds and trinitrile compounds and the values for Formula (1) in Embodiments 2, 18, 25, and Comparison Case 6.

Example	Dinitrile wt % (X)	Trinitrile wt % (Y)	Formula (1) (X + Y)
Embodiment 2	4	0.8	4.8
Embodiment 18	4	5	9
Embodiment 25	4	2.0	6.0
Comparison Case 6	4	0.5	4.5

Table 2: Calculation of Formula (1) for Hong's Embodiments 2, 18, 25, and Comparison Case 6

f. [1.e]: “and Formula (2). . . about $0.1 \leq (X/Y) \leq$ about 8 (2),”

96. In my opinion, Hong discloses electrolytes satisfying Formula (2).

97. Embodiments 2, 18, 25, and Comparison Case 6 contain 2 wt % of the dinitrile compound adiponitrile (ADN), 1 wt % of the dinitrile compound

succinonitrile (SN), and 1 wt % of the dinitrile compound ethylene glycol bis(propionitrile) ether (DENE). Ex. 1005, ¶¶34-35. The total weight percentage of the dinitrile compounds for those examples is 4 wt % (i.e., $X = 4$ wt %).

98. Embodiment 2 contains 0.8 wt % of the trinitrile Compound I₁. Ex. 1005, ¶34. Thus, for Embodiment 2, $Y = 0.8$ wt %.

99. Embodiment 18 contains 5 wt % of the trinitrile Compound I₁. Ex. 1005, ¶35. Thus, for Embodiment 18, $Y = 5$ wt %.

100. Embodiment 25 contains 1.5 wt % of the trinitrile Compound II₆ and 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. The total weight percentage of the dinitrile compounds for Embodiment 25 is 2.0 wt % (i.e., $Y = 2.0$ wt %).

101. Comparison Case 6 contains 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. Thus, for Comparison Case 6, $Y = 0.5$ wt %.

102. In my opinion, Hong discloses electrolytes satisfying Formula (2). Embodiment 2 discloses an electrolyte wherein $X/Y = 4/0.8 = 5$. Embodiment 18 discloses an electrolyte wherein $X/Y = 4/5 = 0.8$. Embodiment 25 discloses an electrolyte wherein $X/Y = 4/2.0 = 2.0$. Comparison Case 6 discloses an electrolyte wherein $X/Y = 4/0.5 = 8.0$.

103. Table 3 summarizes the weight proportion of dinitrile compounds and trinitrile compounds and calculation of Formula (2) for Embodiments 2, 18, 25, and Comparison Case 6.

Example	Dinitrile wt % (X)	Trinitrile wt % (Y)	Formula (2) (X/Y)
Embodiment 2	4	0.8	5.0
Embodiment 18	4	5	0.8
Embodiment 25	4	2.0	2.0
Comparison Case 6	4	0.5	8.0

Table 3: Calculation of Formula (2) for Hong's Embodiments 2, 18, 25, and Comparison Case 6

- g. [1.f]: “wherein, based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z, where Y and Z meet a condition represented by Formula (3): about $0.01 \leq (Y/Z) \leq$ about 0.3 (3).”

104. In my opinion, Hong discloses electrolytes satisfying Formula (3).

105. Embodiments 2, 18, 25, and Comparison Case 6 disclose electrolytes that incorporate one or more lithium salts, a base organic solvent, liquid additives, and solid additives. Ex. 1005, ¶¶34-35. As described in Sections XI.A.1.e and XI.A.1.f above, Embodiment 2 contains 0.8 wt % of the trinitrile Compound I₁ (i.e., Y = 0.8 wt %). Ex. 1005, ¶34. Embodiment 18 contains 5 wt % of the trinitrile Compound I₁ (i.e., Y = 5 wt %). Ex. 1005, ¶35. Embodiment 25 contains 1.5 wt %

of the trinitrile Compound II₆ and 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN) (i.e., Y = 2.0 wt %). Ex. 1005, ¶35. Comparison Case 6 contains 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN) (i.e., Y = 0.5 wt %). Ex. 1005, ¶35.

106. Hong further discloses that propyl propionate (PP) accounts for 25 wt % of the base solvent for Embodiments 2, 18, 25, and CC6. Ex. 1005, ¶¶34-35. That base solvent is then mixed with lithium salt(s) and various additives to produce the exemplary electrolytes. Ex. 1005, ¶¶25-29, 34-35. I have replicated again below the table that Hong provides in paragraphs 34-35 describing the composition of each exemplary electrolyte. *See* Table 4. “[P]ercentage refers to the mass percentage in the final electrolyte, and concentration refers to the concentration in the final electrolyte.” Ex. 1005, ¶38. I have highlighted the **trinitrile compounds in green** and the **propyl propionate component in red**.

	Organic solvent (wt ratio)	Additive (wt %)	Functional compound (wt %)	Electrolyte substance
Embodiment 2	EC: PP :DEC:PC = 25: 25 :40:10	3% PS, 5% FEC, 2% ADN, 1% SN, 0.3% VEC, 1% DENE	0.8% Compound I₁	1.1 M LiPF ₆
Embodiment 18	EC: PP :DEC:PC = 25: 25 :40:10	3% PS, 5% FEC, 2% ADN, 1% SN, 0.3% VEC, 1% DENE	5% Compound I₁	1.1 M LiPF ₆

Embodiment 25	EC:PP:DEC:PC = 25:25:40:10	3% PS, 5% FEC, 2% ADN, 1% SN, 0.5% DTD, 1% DENE, 0.5% HTCN	1.5% Compound II ₆	1.0 M LiPF ₆ +0.5 M LiTFSI
Comparison Case 6	EC:PP:DEC:PC = 25:25:40:10	3% PS, 5% FEC, 2% ADN, 1% SN, 0.5% DTD, 1% DENE, 0.5% HTCN	--	1.0 M LiPF ₆ +0.5 M LiTFSI

Table 4: *Composition of Hong's Embodiments 2, 18, 25, and Comparison Case 6*

107. To calculate the weight percentage of propyl propionate in the total electrolyte (Z) for Embodiments 2, 18, 25, and Comparison Case 6, I have used the electrolyte preparation method taught by Hong to calculate the weight proportion of each electrolyte component. In my opinion, this process is consistent with the process that a person of ordinary skill in the art would have used in determining the weight percentage of propyl propionate in Hong's electrolytes.

108. Hong discloses that Embodiments 2, 18, 25, and Comparison Case 6 were prepared by “mixing, in an argon atmosphere glove box, [base] organic solvents according to a mass ratio; and then adding an additive, a tricyanophosphite compound or tricyanophosphate compound, and an electrolyte substance and stirring well.” Ex. 1005, ¶26. For Embodiments 2, 18, 25, and Comparison Case 6, the base organic solvent is 25 wt % propyl propionate (PP), 25 wt % ethylene carbonate (EC),

40 wt % diethyl carbonate (DEC), and 10 wt % propylene carbonate (PC). Ex. 1005, ¶¶34-35.

109. In calculating the weight percentages of the components in Embodiments 2, 18, 25, and Comparison Case 6, I have made three assumptions: (1) the total volume of the liquid components does not meaningfully change upon mixing; (2) the solid components do not meaningfully contribute to the total volume of the electrolyte; and (3) Hong's tricyanophosphite and tricyanophosphate compounds are liquids at room temperature with a density of 0.60 g/cm³. In my opinion, these are the same assumptions that a person of ordinary skill in the art would have used in determining the weight percentage of propyl propionate in Hong's electrolytes.

110. First, I have assumed that the total volume of the liquid components does not meaningfully change after they are mixed. In other words, if one were to mix 25 ml of propyl propionate (PP) and 25 ml of propylene carbonate (PC), the resulting mixture would have a volume of 50 ml. In my experience, this assumption is justified based on the similarity of the liquid components in Embodiments 2, 18, 25, and Comparison Case 6. For example, since the polarity of the liquid components is similar, it is unlikely that there will be a meaningful change in volume in comparison to adding the individual volumes.

111. Hong discloses two types of liquid components: solvents and liquid additives. The solvents are propyl propionate (PP), ethylene carbonate (EC), diethyl carbonate (DEC), and propylene carbonate (PC). Ex. 1005, ¶¶34-35. Propyl propionate (PP), diethyl carbonate (DEC), and propylene carbonate (PC) are liquid at room temperature. Ex. 1020, 5; Ex. 1011, 4; Ex. 1019, 5. Ethylene carbonate (EC) has long been known to function as a solvent when mixed with liquids, which is consistent with how Hong describes its role. Ex. 1025, 127; Ex. 1026; Ex. 1005, ¶¶13-14, 34-35. The liquid additives are liquid at room temperature and include adiponitrile (ADN), vinyl ethylene carbonate (VEC), ethylene glycol bis(propionitrile) ether (DENE), fluoroethylene carbonate (FEC), and 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1010, 5; Ex. 1024, 4; Ex. 1012, 3; Ex. 1015, 5; Ex. 1016, 5.

112. Second, I have assumed that the solid components (“solutes”) do not meaningfully contribute to the total volume of the electrolyte. When solutes are dissolved in a solvent (here, the liquid component mixture), the molecules in the solvent rearrange to form solvation shells that surround the solute. In my experience, these solvation shells rearrange the solvent molecules in the electrolyte such that the solutes do not meaningfully contribute to the total volume of the electrolyte. To the extent that they do contribute to the total volume of the electrolyte, they may reduce the total volume because they pull the solvent molecules closer together. Even if they

add to the total volume of the electrolyte, the solutes will at most add their volume as solids at room temperature.

113. Hong discloses two types of solid components: lithium salt(s) and solid additives. Embodiments 2, 18, 25, and Comparison Case 6 all contain LiPF_6 as a lithium salt. Embodiment 25 and Comparison Case also contain the lithium salt LiTFSI. The solid additives are solid at room temperature and include succinonitrile (SN), 1,3-propane sultone (PS), and ethylene sulfate (DTD). Ex. 1022, 5; Ex. 1021, 6; Ex. 1013, 5.

114. Finally, I have assumed that the tricyanophosphite and tricyanophosphite compounds disclosed in Hong are liquid at room temperature and have a density of 0.60 g/cm^3 . This assumption captures the maximum reasonable effect that the tricyanophosphite and tricyanophosphite compounds could have in reducing the proportion of propyl propionate in Hong's electrolytes. The lower the density of liquid tricyanophosphite and tricyanophosphite compounds, the lower the proportion of propyl propionate in the total electrolyte. For these calculations, I have assumed a density for the tricyanophosphite and tricyanophosphite compounds that is lower than the density of the least dense common organic compound. *See* Ex. 1027.

115. Using these assumptions, I have calculated below the weight percentage of each component in Embodiments 2, 18, 25, and Comparison Case 6

with respect to the total weight of the electrolyte. Two primary equations guided my calculations. First, the total mass of the electrolyte (m_{total}) equals the mass of the base solvent ($m_{\text{base solvent}}$) plus the mass of the additives ($m_{\text{additives}}$) plus the mass of the lithium salt(s) ($m_{\text{lithium salts}}$):

$$m_{\text{total}} = m_{\text{base solvent}} + m_{\text{additives}} + m_{\text{lithium salts}}$$

Second, the total volume of the electrolyte (V_{total}) equals the volume of the base solvent ($V_{\text{base solvent}}$) plus the volume of the liquid additives ($V_{\text{liquid additives}}$):

$$V_{\text{total}} = V_{\text{base solvent}} + V_{\text{liquid additives}}$$

116. Starting with 100 grams of the base solvent, I calculated the volume of the base solvent using the masses and densities of each individual component. For every 100 grams of the base solvent, ethylene carbonate (EC) accounts for 25.00 grams, propyl propionate (PP) for 25.00 grams, diethyl carbonate (DEC) for 40.00 grams, and propylene carbonate for 10.00 grams. For each solvent component, the volume (V) equals the mass (m) divided by the density (ρ): $V = m/\rho$. Exs. 1014, 1020, 1011, 1019. Based on the density of each component, ethyl carbonate (EC) accounts for 18.93 ml of the organic solvent, propyl propionate (PP) for 28.38 ml, diethyl carbonate (DEC) for 41.03 ml, and propylene carbonate (PC) for 8.31 ml. The total volume of 100 g of the organic solvent is 96.65 ml.

117. Hong discloses the proportion of the additives as a mass percentage of the final electrolyte. Ex. 1005, ¶26. Using an initial estimate of the final electrolyte

mass, I calculated the mass of each additive using the mass percentages provided by Hong. I used the densities (ρ) and calculated masses (m) of the liquid additives to calculate their volume (V), again using the equation $V = m/\rho$. Exs. 1010, 1012, 1015-1016.

118. I added the volume of the liquid additives to the volume of the base solvent to calculate the total electrolyte volume. I used this calculated total electrolyte volume ($V_{\text{calculated total}}$), the concentration of each lithium salt ($C_{\text{lithium salt}}$), and the molecular weight of each lithium salt ($MW_{\text{lithium salt}}$) to calculate the mass of each lithium salt ($m_{\text{lithium salt}}$) based on the equation $m_{\text{lithium salt}} = C_{\text{lithium salt}} MW_{\text{lithium salt}} V_{\text{calculated total}}$. Exs. 1017-1018.

119. I then added the masses of the base solvent, the additives, and the lithium salt(s) to determine the total electrolyte mass. If there was a difference between this calculation of the total electrolyte mass and my initial estimate of the total electrolyte mass, I repeated this process until the calculated total electrolyte mass matched the initial estimate of total electrolyte mass. The calculated mass matching the estimated mass meant that the calculations correctly accounted for the mass ratio, mass percentage, or concentration of each component described in Hong.

120. Because the weight percentage and mass percentage are interchangeable (weight equals mass times gravitational acceleration), the calculated mass matching the estimated mass also allowed me to calculate the weight

percentage of propyl propionate in the total electrolyte (Z) by dividing the mass of propyl propionate (m_{PP}) by the mass of the total electrolyte (m_{total}): $Z = \frac{m_{PP}}{m_{total}}$. In my opinion, this is the same process that a person of ordinary skill in the art would have used in determining the weight percentage of propyl propionate in Hong's electrolytes.

121. The weight percentages of the components in Embodiment 2 are shown in Table 5 below.

	Compound	Density	Volume	Contribution	Wt%
Base Solvent		g/ml	Vol, ml	Weight, g	Total Electrolyte
	EC	1.321	18.93	25.00	
	PP	0.881	28.38	25.00	
	DEC	0.975	41.03	40.00	
	PC	1.204	8.31	10.00	
	Sum Base Solvent	N/A	96.65	100.00	
Liquid Additives	ADN	0.961	2.83	2.72	2.00
	VEC	1.188	0.35	0.41	0.30
	DENE	1.07	1.27	1.36	1.00
	FEC	1.485	4.57	6.79	5.00
	Compound I ₁	0.60	1.82	1.09	0.80
	Sum Liquid Additives	N/A	10.84	12.37	
	Sum Liquid Components	N/A	107.49	112.37	
Solid Additives	SN	0.985	0.00	1.36	1.00
	PS	1.392	0.00	4.07	3.00
Lithium Salt	LiPF ₆ (1.1 M; MW = 151.91 g/mol)	2.83	0.00	17.96	
	Sum Solid Components	N/A	0.00	23.39	
	Sum All Components	N/A	107.49	135.76	
	PP weight %			18.4%	

Table 5: Weight Percentage of Components in Embodiment 2 of Hong

122. As can be seen from Table 5, propyl propionate accounts for 18.4 wt % of the total electrolyte in Embodiment 2 (i.e., Z = 18.4 wt %). As described in Sections XI.A.1.e and XI.A.1.f above, Embodiment 2 contains 0.8 wt % of trinitrile compounds (i.e., Y = 0.8 wt %). Entering these values into Formula (3), $Y/Z = 0.8/18.4 = 0.043$. Thus, in my opinion, Embodiment 2 satisfies Formula (3).

123. The weight percentages of the components in Embodiment 18 are shown in Table 6 below.

	Compound	Density	Volume	Contribution	Wt%
Base Solvent		g/ml	Vol, ml	Weight, g	Total Electrolyte
	EC	1.321	18.93	25.00	
	PP	0.881	28.38	25.00	
	DEC	0.975	41.03	40.00	
	PC	1.204	8.31	10.00	
	Sum Base Solvent	N/A	96.65	100.00	
Liquid Additives	ADN	0.961	3.02	2.90	2.00
	VEC	1.188	0.36	0.43	0.30
	DENE	1.07	1.36	1.45	1.00
	FEC	1.485	4.88	7.24	5.00
	Compound I ₁	0.60	12.07	7.24	5.00
	Sum Liquid Additives	N/A	21.69	19.26	
	Sum Liquid Components	N/A	118.34	119.26	
Solid Additives	SN	0.985	0.00	1.45	1.00
	PS	1.392	0.00	4.34	3.00
Lithium Salt	LiPF ₆ (1.1 M; MW = 151.91 g/mol)	2.83	0.00	19.77	
	Sum Solid Components	N/A	0.00	25.56	
	Sum All Components	N/A	118.34	144.82	
	PP weight %			17.3%	

Table 6: Weight Percentage of Components in Embodiment 18 of Hong

124. As can be seen from Table 6, propyl propionate accounts for 17.3 wt % of the total electrolyte in Embodiment 18 (i.e., Z = 17.3 wt %). As described in Sections XI.A.1.e and XI.A.1.f above, Embodiment 18 contains 5 wt % of trinitrile compounds (i.e., Y = 5 wt %). Entering these values into Formula (3), $Y/Z = 5/17.3 = 0.289$. Thus, in my opinion, Embodiment 18 satisfies Formula (3).

125. The weight percentages of the components in Embodiment 25 are shown in Table 7 below.

	Compound	Density	Volume	Contribution	Wt%
Base Solvent		g/ml	Vol, ml	Weight, g	Total Electrolyte
	EC	1.321	18.93	25.00	
	PP	0.881	28.38	25.00	
	DEC	0.975	41.03	40.00	
	PC	1.204	8.31	10.00	
	Sum Base Solvent	N/A	96.65	100.00	
Liquid Additives	ADN	0.961	3.24	3.11	2.00
	DENE	1.07	1.45	1.55	1.00
	FEC	1.485	5.23	7.77	5.00
	HTCN	1.04	0.75	0.78	0.50
	Compound II ₆	0.60	3.88	2.33	1.50
	Sum Liquid Additives	N/A	14.55	15.54	
	Sum Liquid Components	N/A	111.20	115.54	
Solid Additives	SN	0.985	0.00	1.55	1.00
	DTD	1.73	0.00	0.78	0.50
	PS	1.392	0.00	4.66	3.00
Lithium Salts	LiTFSI (0.5 M; MW = 287.09 g/mol)	2.15	0.00	15.96	
	LiPF ₆ (1.0 M; MW = 151.91 g/mol)	2.83	0.00	16.89	
	Sum Solid Components	N/A	0.00	39.84	
	Sum All Components	N/A	111.20	155.38	
	PP weight %			16.1%	

Table 7: Weight Percentage of Components in Embodiment 25 of Hong

126. As can be seen from Table 7, propyl propionate accounts for 16.1 wt % of the total electrolyte in Embodiment 25 (i.e., Z = 16.1 wt %). As described in Sections XI.A.1.e and XI.A.1.f above, Embodiment 25 contains 2.0 wt % of trinitrile compounds (i.e., Y = 2.0 wt %). Entering these values into Formula (3), $Y/Z = 2.0/16.1 = 0.124$. Thus, in my opinion, Embodiment 25 satisfies Formula (3).

127. The weight percentages of the components in Comparison Case 6 are shown in Table 8 below.

	Compound	Density	Volume	Contribution	Wt%
Base Solvent		g/ml	Vol, ml	Weight, g	Total Electrolyte
	EC	1.321	18.93	25.00	
	PP	0.881	28.38	25.00	
	DEC	0.975	41.03	40.00	
	PC	1.204	8.31	10.00	
	Sum Base Solvent	N/A	96.65	100.00	
Liquid Additives	ADN	0.961	3.15	3.03	2.00
	DENE	1.07	1.41	1.51	1.00
	FEC	1.485	5.09	7.56	5.00
	HTCN	1.04	0.73	0.76	0.50
	Sum Liquid Additives	N/A	10.38	12.86	
	Sum Liquid Components	N/A	107.03	112.86	
Solid Additives	SN	0.985	0.00	1.51	1.00
	DTD	1.73	0.00	0.76	0.50
	PS	1.392	0.00	4.54	3.00
Lithium Salts	LiTFSI (0.5 M; MW = 287.09 g/mol)	2.15	0.00	15.36	
	LiPF ₆ (1.0 M; MW = 151.91 g/mol)	2.83	0.00	16.26	
	Sum Solid Components	N/A	0.00	38.43	
	Sum All Components	N/A	107.03	151.29	
	PP weight %			16.5%	

Table 8: Weight Percentage of Components in Comparison Case 6 of Hong

128. As can be seen from Table 8, propyl propionate accounts for 16.5 wt % of the total electrolyte in Comparison Case 6 (i.e., $Z = 16.5$ wt %). As described in Sections XI.A.1.e and XI.A.1.f above, Comparison Case 6 contains 0.5 wt % of trinitrile compounds (i.e., $Y = 0.5$ wt %). Entering these values into Formula (3), $Y/Z = 0.5/16.5 = 0.030$. Thus, in my opinion, Comparison Case 6 satisfies Formula (3).

129. I have summarized these calculations in Table 9 below. The propyl propionate weight percentage in the total electrolyte differs for Embodiments 2, 18, 25, and CC6, despite their having the same propyl propionate weight percentage in the base solvent, because they contain different additives in different proportions.

Example	Trinitrile wt % (Y)	Propyl Propionate wt % (Z)	Formula (3) (Y/Z)
Embodiment 2	0.8	18.4	0.043
Embodiment 18	5	17.3	0.289
Embodiment 25	2.0	16.1	0.124
Comparison Case 6	0.5	16.5	0.030

Table 9: Calculation of Formula (3) for Hong's Embodiments 2, 18, 25, and Comparison Case 6 Using Standard Assumptions for a Person of Ordinary Skill in the Art

130. In my opinion, each of Embodiments 2, 18, 25, and Comparison Case 6 satisfies Formula (3), even if my assumptions are set aside.

131. First, in my opinion, each of Embodiments 2, 18, 25, and Comparison Case 6 satisfies Formula (3), even if mixing the solvents results in a meaningful change to their total volume. If my first assumption is set aside, the total volume of the solvents would reduce upon mixing as the smaller molecules in the solvent occupied the space between the larger molecules. Because propyl propionate accounts for 25 wt % of the solvent for each of Embodiments 2, 18, 25, and Comparison Case 6, propyl propionate can account for no more than 25 wt % of the total electrolyte. Assuming that $Z = 25 \text{ wt } \%$, $Y/Z = 0.8/25 = 0.032$ for Embodiment 2; $Y/Z = 5/25 = 0.200$ for Embodiment 18; $Y/Z = 2.0/25 = 0.080$ for Embodiment 25; and $Y/Z = 0.5/25 = 0.020$ for Comparison Case 6.

132. Second, in my opinion, each of Embodiments 2, 18, 25, and Comparison Case 6 satisfies Formula (3), even if the lithium salt(s) and the solid additives contribute the maximum possible amount to the total volume of the electrolyte. If the lithium salt(s) and the solid additives reduce the total volume of the electrolyte, the weight percentage of propyl propionate can be no more than 25 wt %, as discussed above. If the lithium salt(s) and the solid additives add to the total volume of the electrolyte, the volume they can add will at most equal their volume as solids at room temperature.

133. To adjust my calculations to determine the effect of the lithium salt(s) and solid additives adding to the total volume of the electrolyte, I used similar

equations to the ones described above to guide my calculations. First, the total mass of the electrolyte (m_{total}) equals the mass of the base solvent ($m_{\text{base solvent}}$) plus the mass of the additives ($m_{\text{additives}}$) plus the mass of the lithium salt(s) ($m_{\text{lithium salts}}$):

$$m_{\text{total}} = m_{\text{base solvent}} + m_{\text{additives}} + m_{\text{lithium salts}}$$

Second, the total volume of the electrolyte (V_{total}) equals the volume of the base solvent ($V_{\text{base solvent}}$) plus the volume of the additives ($V_{\text{additives}}$) plus the volume of the lithium salt(s) ($V_{\text{lithium salts}}$):

$$V_{\text{total}} = V_{\text{base solvent}} + V_{\text{additives}} + V_{\text{lithium salts}}$$

134. Again starting with 100 grams of the base solvent, I calculated the volume of the base solvent using the masses and densities of each individual component. For every 100 grams of the base solvent, ethylene carbonate (EC) accounts for 25.00 grams, propyl propionate (PP) for 25.00 grams, diethyl carbonate (DEC) for 40.00 grams, and propylene carbonate for 10.00 grams. For each solvent component, the volume (V) equals the mass (m) divided by the density (ρ): $V = m/\rho$. Exs. 1014, 1020, 1011, 1019. Based on the density of each component, ethyl carbonate (EC) accounts for 18.93 ml of the organic solvent, propyl propionate (PP) for 28.38 ml, diethyl carbonate (DEC) for 41.03 ml, and propylene carbonate (PC) for 8.31 ml. The total volume of 100 g of the organic solvent is 96.65 ml.

135. Hong discloses the proportion of the additives as a mass percentage of the final electrolyte. Ex. 1005, ¶26. Using an initial estimate of the final electrolyte mass, I calculated the mass of each additive. I used that estimated total electrolyte volume ($V_{\text{estimated total}}$), the concentration of each lithium salt ($C_{\text{lithium salt}}$), and the molecular weight of each lithium salt ($MW_{\text{lithium salt}}$) to calculate the mass of each lithium salt ($m_{\text{lithium salt}}$) based on the equation $m_{\text{lithium salt}} = C_{\text{lithium salt}} MW_{\text{lithium salt}} V_{\text{estimated total}}$. Exs. 1017-1018. I added the masses of the organic solvent, additives, and lithium salts to determine the calculated final electrolyte mass.

136. I also used the densities (ρ) and the calculated masses (m) of the additives and lithium salts to calculate their volume (V), again using the equation $V = m/\rho$. Exs. 1010, 1012-1013, 1015-1018, 1021-1022, 1024. I added the volumes of the organic solvent, additives, functional compound, and electrolyte substances to determine the calculated final electrolyte volume.

137. I then compared the calculated final electrolyte mass and volume to the estimated electrolyte mass and volume. If there was a difference between the estimated values and the calculated values, then the initial estimate was incorrect, and so I made a new estimate and repeated the calculation until the estimated values matched the calculated values. When the estimated values matched the calculated values, the calculation accurately reflected the mass ratio, mass percentage, or concentration of each component described in Hong.

138. I have calculated the weight percentage of the components in Embodiment 2 in Table 10 below, assuming that the lithium salt and the solid additives contribute the maximum possible amount to the total volume of the electrolyte.

	Compound	Density	Volume	Contribution	Wt%
Base Solvent		g/ml	Vol, ml	Weight, g	Total Electrolyte
	EC	1.321	18.93	25.00	
	PP	0.881	28.38	25.00	
	DEC	0.975	41.03	40.00	
	PC	1.204	8.31	10.00	
	Sum Base Solvent	N/A	96.65	100.00	
Liquid Additives	ADN	0.961	2.87	2.76	2.00
	VEC	1.188	0.35	0.41	0.30
	DENE	1.07	1.29	1.38	1.00
	FEC	1.485	4.65	6.90	5.00
	Compound I ₁	0.60	1.83	1.10	0.80
	Sum Liquid Additives	N/A	10.99	12.55	
	Sum Liquid Components	N/A	107.64	112.55	
Solid Additives	SN	0.985	1.40	1.38	1.00
	PS	1.392	2.97	4.14	3.00
Lithium Salt	LiPF ₆ (1.1 M; MW = 151.91 g/mol)	2.83	7.03	19.89	
	Sum Solid Components	N/A	11.40	25.41	
	Sum All Components	N/A	119.04	137.96	
	PP weight %			18.1%	

Table 10: Weight Percentage of Components in Embodiment 2 of Hong if the Lithium Salt and Solid Additives Contribute to Total Volume

139. As can be seen from Table 10, if the lithium salt and solid additives contribute the maximum possible amount to the total volume of the electrolyte, propyl propionate accounts for 18.1 wt % of the total electrolyte in Embodiment 2 (i.e., Z = 18.1 wt %). As described in Sections XI.A.1.e and XI.A.1.f above,

Embodiment 2 contains 0.8 wt % of trinitrile compounds (i.e., Y = 0.8 wt %).

Entering these values into Formula (3), $Y/Z = 0.8/18.1 = 0.044$. Thus, in my opinion, Embodiment 2 satisfies Formula (3), even if the lithium salt and solid additives contribute the maximum possible amount to the total volume of the electrolyte.

140. I have calculated the weight percentage of the components in Embodiment 18 in Table 11 below, assuming that the lithium salt and the solid additives contribute the maximum possible amount to the total volume of the electrolyte.

	Compound	Density	Volume	Contribution	Wt%
Base Solvent		g/ml	Vol, ml	Weight, g	Total Electrolyte
	EC	1.321	18.93	25.00	
	PP	0.881	28.38	25.00	
	DEC	0.975	41.03	40.00	
	PC	1.204	8.31	10.00	
	Sum Base Solvent	N/A	96.65	100.00	
Liquid Additives	ADN	0.961	3.07	2.95	2.00
	VEC	1.188	0.37	0.44	0.30
	DENE	1.07	1.37	1.47	1.00
	FEC	1.485	4.96	7.37	5.00
	Compound I ₁	0.60	12.28	7.37	5.00
	Sum Liquid Additives	N/A	22.05	19.60	
	Sum Liquid Components	N/A	118.70	119.60	
Solid Additives	SN	0.985	1.49	1.47	1.00
	PS	1.392	3.18	4.42	3.00
Lithium Salt	LiPF ₆ (1.1 M; MW = 151.91 g/mol)	2.83	7.74	21.91	

	Sum Solid Components	N/A	12.41	27.80
	Sum All Components	N/A	131.11	147.40
	PP weight %			17.0%

Table 11: *Weight Percentage of Components in Embodiment 18 of Hong if the Lithium Salt and Solid Additives Contribute to Total Volume*

141. As can be seen from Table 11, if the lithium salt and solid additives contribute the maximum possible amount to the total volume of the electrolyte, propyl propionate accounts for 17.0 wt % of the total electrolyte in Embodiment 18 (i.e., $Z = 17.0$ wt %). As described in Sections XI.A.1.e and XI.A.1.f above, Embodiment 18 contains 5 wt % of trinitrile compounds (i.e., $Y = 5$ wt %). Entering these values into Formula (3), $Y/Z = 5/17.0 = 0.294$. Thus, in my opinion, Embodiment 18 satisfies Formula (3), even if the lithium salt and solid additives contribute the maximum possible amount to the total volume of the electrolyte.

142. I have calculated the weight percentages of the components in Embodiment 25 in Table 12 below, assuming that the lithium salt(s) and the solid additives contribute the maximum possible amount to the total volume of the electrolyte.

	Compound	Density	Volume	Contribution	Wt%
		g/ml	Vol, ml	Weight, g	Total Electrolyte
Base Solvent	EC	1.321	18.93	25.00	
	PP	0.881	28.38	25.00	
	DEC	0.975	41.03	40.00	
	PC	1.204	8.31	10.00	
	Sum Base Solvent	N/A	96.65	100.00	
	ADN	0.961	3.39	3.26	2.00

Liquid Additives	DENE	1.07	1.52	1.63	1.00
	FEC	1.485	5.49	8.16	5.00
	HTCN	1.04	0.79	0.82	0.50
	Compound II ₆	0.60	4.08	2.45	1.50
	Sum Liquid Additives	N/A	15.27	16.32	
	Sum Liquid Components	N/A	111.92	116.32	
Solid Additives	SN	0.985	1.65	1.63	1.00
	DTD	1.73	0.47	0.82	0.50
	PS	1.392	3.51	4.89	3.00
Lithium Salts	LiTFSI (0.5 M; MW = 287.09 g/mol)	2.15	8.92	19.18	
	LiPF ₆ (1.0 M; MW = 151.91 g/mol)	2.83	7.17	20.30	
	Sum Solid Components	N/A	21.72	46.82	
	Sum All Components	N/A	133.64	163.14	
	PP weight %			15.3%	

Table 12: *Weight Percentage of Components in Embodiment 25 of Hong if the Lithium Salt and Solid Additives Contribute to Total Volume*

143. As can be seen from Table 12, if the lithium salt and solid additives contribute the maximum possible amount to the total volume of the electrolyte, propyl propionate accounts for 15.3 wt % of the total electrolyte in Embodiment 25 (i.e., $Z = 15.3$ wt %). As described in Sections XI.A.1.e and XI.A.1.f above, Embodiment 25 contains 2.0 wt % of trinitrile compounds (i.e., $Y = 2.0$ wt %). Entering these values into Formula (3), $Y/Z = 2.0/15.3 = 0.131$. Thus, in my opinion, Embodiment 25 satisfies Formula (3), even if the lithium salt and solid additives contribute the maximum possible amount to the total volume of the electrolyte.

144. I have calculated the weight percentage of the components in Comparison Case 6 in Table 13 below, assuming that the lithium salt(s) and the solid

additives contribute the maximum possible amount to the total volume of the electrolyte.

	Compound	Density	Volume	Contribution	Wt%
Base Solvent		g/ml	Vol, ml	Weight, g	Total Electrolyte
	EC	1.321	18.93	25.00	
	PP	0.881	28.38	25.00	
	DEC	0.975	41.03	40.00	
	PC	1.204	8.31	10.00	
	Sum Base Solvent	N/A	96.65	100.00	
Liquid Additives	ADN	0.961	3.30	3.17	2.00
	DENE	1.07	1.49	1.59	1.00
	FEC	1.485	5.34	7.93	5.00
	HTCN	1.04	0.76	0.79	0.50
	Sum Liquid Additives	N/A	10.89	13.48	
	Sum Liquid Components	N/A	107.54	113.48	
Solid Additives	SN	0.985	1.61	1.59	1.00
	DTD	1.73	0.46	0.79	0.50
	PS	1.392	3.42	4.76	3.00
Lithium Salts	LiTFSI (0.5 M; MW = 287.09 g/mol)	2.15	8.58	18.45	
	LiPF ₆ (1.0 M; MW = 151.91 g/mol)	2.83	6.90	19.52	
	Sum Solid Components	N/A	20.97	45.11	
	Sum All Components	N/A	128.51	158.59	
	PP weight %			15.8%	

Table 13: Weight Percentage of Components in Comparison Case 6 of Hong if the Lithium Salt and Solid Additives Contribute to Total Volume

145. As can be seen from Table 13, if the lithium salt and solid additives contribute the maximum possible amount to the total volume of the electrolyte, propyl propionate accounts for 15.8 wt % of the total electrolyte in Comparison Case 6 (i.e., Z = 15.8 wt %). As described in Sections XI.A.1.e and XI.A.1.f above, Comparison Case 6 contains 0.5 wt % of trinitrile compounds (i.e., Y = 0.5 wt %).

Entering these values into Formula (3), $Y/Z = 0.5/15.8 = 0.032$. Thus, in my opinion, Comparison Case 6 satisfies Formula (3), even if the lithium salt and solid additives contribute the maximum possible amount to the total volume of the electrolyte.

146. Third, in my opinion, my third assumption already represents the lowest reasonable density for the tricyanophosphite and tricyanophosphate compounds. In fact, the weight percentages of propyl propionate in Embodiments 2, 18, 25, and Comparison Case 6 would likely be higher than the values I have calculated here given the similarity of propyl propionate to compounds having a higher density. Further, as my calculations demonstrate, the tricyanophosphite and tricyanophosphate compounds are included in such small amounts that even a large difference in their density would not meaningfully affect the weight percentage of propyl propionate in the final electrolyte.

147. Finally, in my opinion, each of Embodiments 2, 18, 25, and Comparison Case 6 satisfies Formula (3), even if all my assumptions are set aside. My assumptions have offsetting implications for the weight percentage of propyl propionate.

148. If my first and/or third assumptions are set aside, the weight percentage of propyl propionate would increase, but in no case would it be above 25 wt % (its weight percentage in the base solvent). The actual upper bound for the weight percentage of propyl propionate would be less than 25 wt %. Hong's electrolytes

comprise a base solvent, lithium salt(s), and additives. Propyl propionate is 25 wt % of the base solvent, but that number does not account for the weight of the lithium salt(s) or additives.

149. If my second assumption is set aside, the weight percentage of propyl propionate could increase, but as discussed above, it could not be above 25 wt %. If, however, the lithium salt(s) and solid additives increased the total volume of the electrolyte, the maximum volume increase would equal their volume as solids at room temperature. As discussed, the weight percentage of propyl propionate in this scenario would be no less than 18.1 wt % for Embodiment 2, 17.0 wt % for Embodiment 18, 15.3 wt % for Embodiment 25, and 15.8 wt % for Comparison Case 6.

150. Thus, if my assumptions are set aside, the weight percentage of propyl propionate could be no more than 25 wt % and no less than 15.3-18.1 wt % (depending on the embodiment). I have summarized these calculations in Table 14 below.

Example	Maximum Propyl Propionate (PP) wt %	Minimum Propyl Propionate (PP) wt %
Embodiment 2	25	18.1
Embodiment 18	25	17.0
Embodiment 25	25	15.3
Comparison Case 6	25	15.8

Table 14: Maximum and Minimum Propyl Propionate Weight Percentage for Hong's Embodiments 2, 18, 25, and Comparison Case 6 if the Assumptions Are Set Aside

151. Each value within that range satisfies Formula (3) for Embodiments 2, 18, 25, and Comparison Case 6 of Hong, as shown in Table 15 below.

Example	Maximum Value for Formula (3) (Y/Z)	Minimum Value for Formula (3) (Y/Z)
Embodiment 2	0.044	0.032
Embodiment 18	0.294	0.200
Embodiment 25	0.131	0.080
Comparison Case 6	0.032	0.020

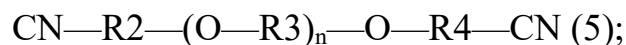
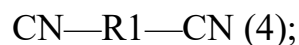
Table 15: Maximum and Minimum Values for Formula (3) for Hong's Embodiments 2, 18, 25, and Comparison Case 6 if the Assumptions Are Set Aside

2. **Claim 2:** “The electrolyte according to claim 1, wherein the dinitrile compound comprises a compound of Formula (4) or (5). . . .”

152. In my opinion, Hong anticipates claim 2.

153. Claim 2 of the '363 patent recites:

The electrolyte according to claim 1, wherein the dinitrile compound comprises a compound of Formula (4) or (5):



or a combination thereof,

where R1, R2, R3 and R4 are each independently an alkylene group having 1-5 carbon atoms or an alkenylene group having 2-5 carbon atoms, and n represents an integer from 0 to 5.

Ex. 1001, claim 2.

154. As explained in Section XI.A.1 above, Hong discloses example electrolyte embodiments containing the dinitrile compounds succinonitrile (SN), adiponitrile (ADN), and ethylene glycol bis(propionitrile) ether (DENE). Each of Embodiments 2, 18, 25, and Comparison Case 6 discloses an electrolyte containing succinonitrile (SN), adiponitrile (ADN), and ethylene glycol bis(propionitrile) ether (DENE). Ex. 1005, ¶¶34-35.

155. Succinonitrile (SN) is a compound of Formula (4), wherein R1 is an alkylene group having 2 carbon atoms, as shown in Figure 19 below.

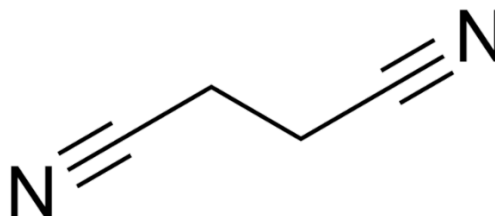


Figure 19: Structure of Succinonitrile (SN)

156. Adiponitrile (ADN) is a compound of Formula (4), wherein R1 is an alkylene group having 4 carbon atoms, as shown in Figure 20 below.

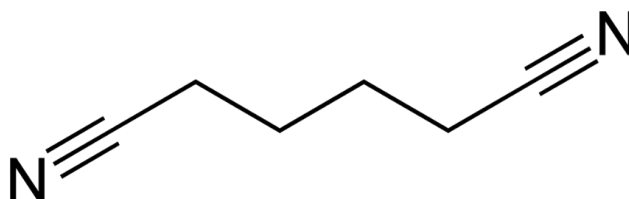


Figure 20: Structure of Adiponitrile (ADN)

157. Ethylene glycol bis(propionitrile) ether (DENE) is a compound of Formula (5), wherein R2, R3, and R4 are each alkylene groups having 2 carbon atoms and n is 1, as shown in Figure 21 below.

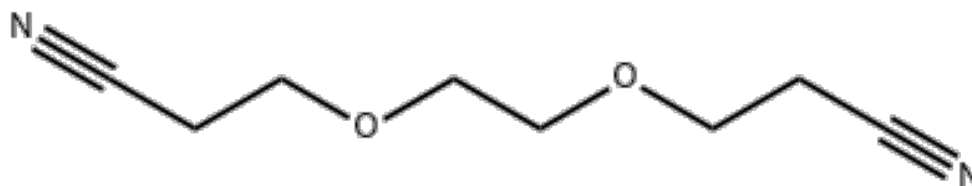


Figure 21: Structure of DENE

3. **Claim 3:** “The electrolyte according to claim 1, wherein the dinitrile compound is one selected from the group consisting of

butanedinitrile. . . adiponitrile. . . ethylene glycol bis(2-cyanoethyl)ether. . . and any combination thereof.”

158. In my opinion, Hong anticipates claim 3.

159. As explained in Section XI.A.1 above, Hong discloses example electrolyte embodiments containing the dinitrile compounds succinonitrile (SN), adiponitrile (ADN), and ethylene glycol bis(propionitrile) ether (DENE). Ex. 1005, ¶¶34-35. Each of Embodiments 2, 18, 25, and Comparison Case 6 discloses an electrolyte containing succinonitrile (SN), adiponitrile (ADN), and ethylene glycol bis(propionitrile) ether (DENE). Ex. 1005, ¶¶34-35. A person of ordinary skill in the art would understand that butanedinitrile and succinonitrile are alternative names for the same compound. *See* Ex. 1022, 2. A person of ordinary skill in the art would also understand that ethylene glycol bis(2-cyanoethyl)ether and ethylene glycol bis(propionitrile) ether are alternative names for the same compound. Ex. 1012, 2.

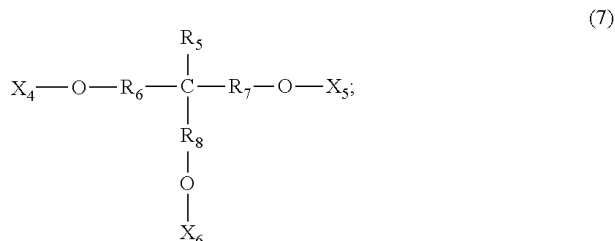
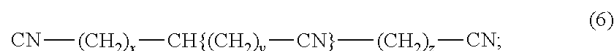
4. Claim 4: “The electrolyte according to claim 1, wherein the trinitrile compound comprises a compound of Formula (6) or (7). . . .”

160. In my opinion, Hong anticipates claim 4.

161. Claim 4 of the ’363 patent recites:

The electrolyte according to claim 1,

wherein the trinitrile compound comprises a compound of
Formula (6) or (7):



or a combination thereof,

where in Formula (6), x, y, and z represent an integer from 0 to 5, and x, y, and z are not 0 at the same time; and

in Formula (7), R5 represents hydrogen or an alkyl group having 1-5 carbon atoms, R6, R7 and R8 are each independently an alkylene group having 1-5 carbon atoms, and X4, X5 and X6 are each independently —R9—CN, in which R9 represents an alkylene group having 1-5 carbon atoms.

Ex. 1001, claim 4.

162. As explained in Section XI.A.1 above, Hong discloses example electrolyte embodiments containing the trinitrile compound 1,3,6-hexane tricarbonitrile (HTCN). Each of Embodiment 25 and Comparison Case 6 contain 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35.

163. 1,3,6-hexane tricarbonitrile (HTCN) is a trinitrile compound of Formula (6), wherein x = 2, y = 0, and z = 3, as shown in Figure 22 below.

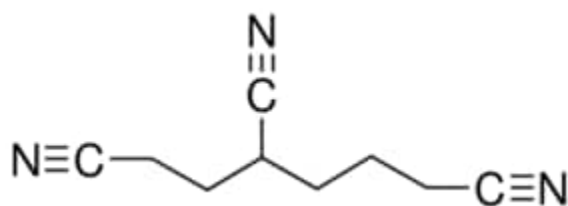


Figure 22: Structure of 1,3,6-hexane tricarbonitrile (HTCN)

164. Embodiment 25 and Comparison Case 6 each satisfy Formulas (1)-(3) even if Y only includes the 1,3,6-hexanetricarbonitrile (HTCN) component. In that scenario, for Embodiment 25, Formula (1) $(X+Y) = 4 + 0.5 = 4.5$; Formula (2) $(X/Y) = 4/0.5 = 8$; and Formula (3) $(Y/Z) = 0.5/16.1 = 0.031$; and for Comparison Case 6, Formula (1) $(X+Y) = 4 + 0.5 = 4.5$; Formula (2) $(X/Y) = 4/0.5 = 8$; and Formula (3) $(Y/Z) = 0.5/16.5 = 0.030$.

5. **Claim 5: “The electrolyte according to claim 1, wherein the trinitrile compound is one selected from the group consisting of . . . 1,3,6-hexanetricarbonitrile. . . .”**

165. In my opinion, Hong anticipates claim 5.

166. As explained in Section XI.A.1 above, Hong discloses example electrolyte embodiments containing the trinitrile compound 1,3,6-hexane tricarbonitrile (HTCN). Each of Embodiment 25 and Comparison Case 6 contains 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35.

167. Embodiment 25 and Comparison Case 6 each satisfy Formulas (1)-(3) even if Y only includes the 1,3,6-hexanetricarbonitrile (HTCN) component. In that scenario, for Embodiment 25, Formula (1) $(X+Y) = 4 + 0.5 = 4.5$; Formula (2) (X/Y)

= $4/0.5 = 8$; and Formula (3) $(Y/Z) = 0.5/16.1 = 0.031$; and for Comparison Case 6, Formula (1) $(X+Y) = 4 + 0.5 = 4.5$; Formula (2) $(X/Y) = 4/0.5 = 8$; and Formula (3) $(Y/Z) = 0.5/16.5 = 0.030$.

6. Claim 6

168. In my opinion, Hong anticipates claim 6.

a. [6pre]: “The electrolyte according to claim 1,”

169. As explained in Section XI.A.1 above, it is my opinion that Hong discloses electrolytes according to claim 1, including Embodiments 2, 18, and 25 and Comparison Case 6.

b. [6.a]: “wherein X is about 0.01-10 wt %,”

170. In my opinion, Hong further discloses electrolytes “wherein X is about 0.01-10 wt %.” Embodiments 2, 18, 25, and Comparison Case 6 contain 4 wt % of dinitrile compounds (i.e., $X = 4$ wt %). In particular, Embodiments 2, 18, 25, and Comparison Case 6 contain 2 wt % of the dinitrile compound adiponitrile (ADN), 1 wt % of the dinitrile compound succinonitrile (SN), and 1 wt % of the dinitrile compound ethylene glycol bis(propionitrile) ether (DENE), as explained in Sections XI.A.1.e and XI.A.1.f above. Ex. 1005, ¶¶34-35.

c. [6.b]: “Y is about 0.01-10 wt %,”

171. In my opinion, Hong further discloses electrolytes wherein “Y is about 0.01-10 wt %.” Embodiment 2 contains 0.8 wt % of the trinitrile Compound I₁ (i.e.,

Y = 0.8 wt %). Ex. 1005, ¶34. Embodiment 18 contains 5 wt % of the trinitrile Compound I₁ (i.e., Y = 5 wt %). Ex. 1005, ¶35. Embodiment 25 contains 2.0 total wt % of trinitrile compounds (i.e., Y = 2.0 wt %), 1.5 wt % of the trinitrile Compound II₆ and 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. Comparison Case 6 contains 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN) (i.e., Y = 0.5 wt %). Ex. 1005, ¶35. *See* §§ XI.A.1.e-XI.A.1.g, *supra*.

d. [6.c]: “and a weight percentage Z of the propyl propionate is about 5-50 wt %.”

172. In my opinion, Hong further discloses electrolytes wherein “a weight percentage Z of the propyl propionate is about 5-50 wt %.” As I explained in Section XI.A.1.g, propyl propionate accounts for 18.4 wt % of the total electrolyte in Embodiment 2, 17.3 wt % of the total electrolyte in Embodiment 18, 16.1 wt % of the total electrolyte in Embodiment 25, and 16.5 wt % of the total electrolyte in Comparison Case 6.

173. My opinion does not change if the assumptions that underlie my calculation of the propyl propionate weight percentage are set aside. In my opinion, each of Embodiments 2, 18, 25, and Comparison Case 6 contains a weight percentage of propyl propionate between about 5-50%, even if my first or third assumption is set aside. As I explained in Section XI.A.1.g, if my first or third

assumption is set aside, propyl propionate could account for no more than 25 wt % of the total electrolyte, which falls within the range recited in claim 6 of the '363 patent.

174. It is my further opinion that each of Embodiments 2, 18, 25, and Comparison Case 6 contains a weight percentage of propyl propionate between about 5-50%, if my second assumption is set aside. As I explained in Section XI.A.1.g, to the extent that the lithium salt(s) and the solid additives add to the total volume of the electrolyte, propyl propionate could account for no less than 18.1 wt % of the total electrolyte in Embodiment 2, 17.0 wt % of the total electrolyte in Embodiment 18, 15.3 wt % of the total electrolyte in Embodiment 25, and 15.8 wt % of the total electrolyte in Comparison Case 6.

175. If all my assumptions are set aside, the weight percentage of propyl propionate in the total electrolyte could be no more than 25 wt % and no less than 15.3-18.1 wt % of the total electrolyte, as explained in Section XI.A.1.g. Each of these ranges falls entirely within the range recited in claim 6 of the '363 patent.

7. **Claim 11: “The electrolyte according to claim 1, further comprising one selected from a group consisting of: a cyclic carbonate ester having a carbon-carbon double bond, a fluorinated chain carbonate ester, a fluorinated cyclic carbonate ester, a compound having a sulfur-oxygen double bond, and any combination thereof.”**

176. In my opinion, Hong anticipates claim 11.

177. In my opinion, Hong discloses electrolytes comprising one or more of a cyclic carbonate ester having a carbon-carbon double bond, a fluorinated cyclic carbonate ester, and a compound having a sulfur-oxygen double bond. In particular, Embodiments 2, 18, 25, and Comparison Case 6 contain one or more of a cyclic carbonate ester having a carbon-carbon double bond, a fluorinated cyclic carbonate ester, and a compound having a sulfur-oxygen double bond.

178. Hong states that its electrolyte may contain a “common additive used in the art,” including one or more of fluoroethylene carbonate (FEC), 1,3-propane sultone (PS), vinyl ethylene carbonate (VEC), and ethylene sulfate (DTD). Ex. 1005, ¶15. Embodiments 2, 18, 25, and Comparative Case 6 all contain fluoroethylene carbonate (FEC) and 1,3-propane sultone (PS). Ex. 1005, ¶¶34-35. Fluoroethylene carbonate (FEC) is a fluorinated ethylene carbonate, as shown in Figure 23 below. 1,3-propane sultone (PS) is a compound having a sulfur-oxygen double-bond, as shown in Figure 24 below.

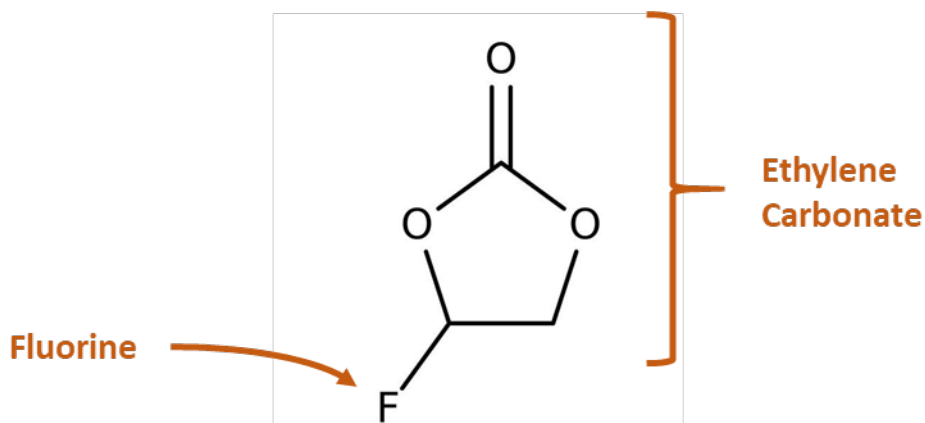


Figure 23: Structure of Fluoroethylene Carbonate (FEC)

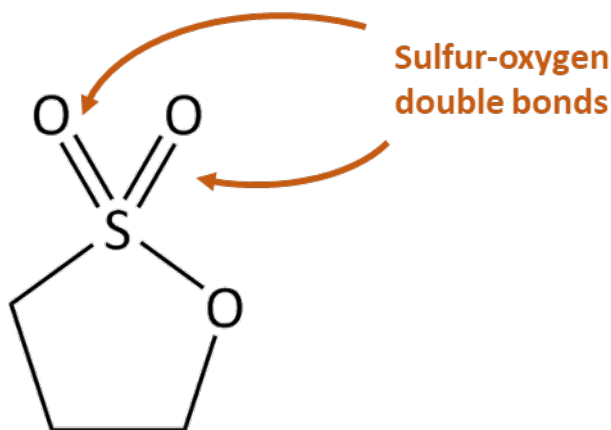


Figure 24: Structure of 1,3-Propane Sultone (PS)

179. Embodiments 2 and 18 contain vinylethylene carbonate (VEC), in addition to FEC and PS. Ex. 1005, ¶¶34-35. Vinylethylene carbonate is a cyclic carbonate ester having a carbon-carbon double bond, as shown in Figure 25 below.

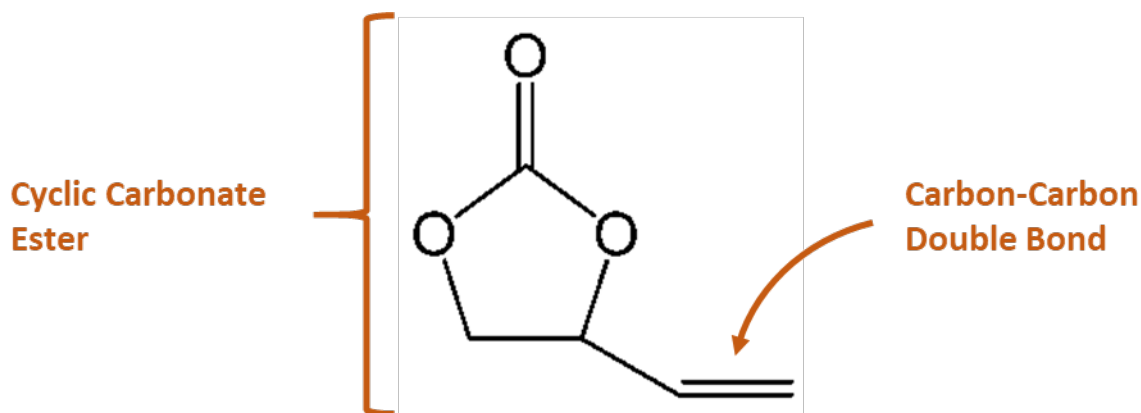


Figure 25: Structure of Vinylethylene Carbonate (VEC)

180. Embodiment 25 and Comparison Case 6 contain ethylene sulfate (DTD), in addition to FEC and PS. Ex. 1005, ¶35. Ethylene sulfate is a compound having a sulfur-oxygen double bond, as shown in Figure 26 below.

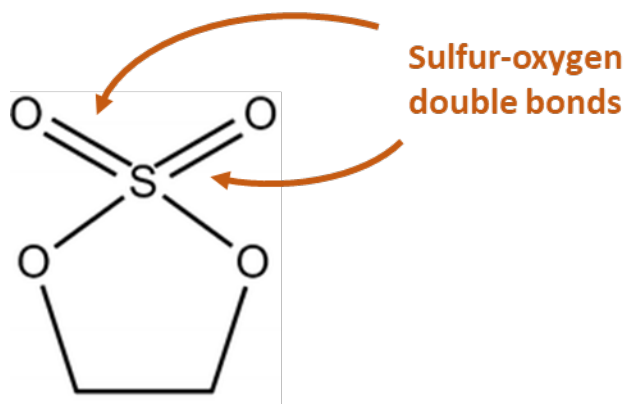


Figure 26: *Structure of Ethylene Sulfate (DTD)*

8. Claim 13

181. In my opinion, Hong anticipates claim 13 of the '363 patent.

a. [13pre]: “An electrochemical device, wherein the electrochemical device comprises”

182. In my opinion, Hong discloses an electrochemical device. Hong states that its invention “belongs to the field of lithium secondary batteries and more particularly relates to an electrolyte and a lithium secondary battery containing the same.” Ex. 1005, ¶1. Embodiments 2, 18, 25, and Comparison Case 6 describe example embodiments of a “lithium secondary battery” containing the described electrolyte. Ex. 1005, ¶25 (“Below are the steps for the manufacturing and performance testing of the lithium secondary battery according to embodiments of the present invention.”); *see also* ¶¶34-35. A person of ordinary skill in the art would understand that a lithium secondary battery is an electrochemical device. *See* Ex. 1001, 18:19-25 (“The electrochemical device of the present invention includes any

device in which an electrochemical reaction takes place. . . . In particular, the electrochemical device is a *lithium secondary battery*. . . .”).

b. [13.a]: “electrodes and”

183. In my opinion, Hong discloses an electrochemical device comprising electrodes. Hong states that “[t]he present invention also relates to a lithium secondary battery containing the aforementioned electrolyte, the lithium secondary battery comprising a positive *electrode* containing a positive electrode active material, a negative *electrode* containing a negative electrode active material, a separator, and the aforementioned electrolyte.” Ex. 1005, ¶16 (emphasis added). Embodiments 2, 18, 25, and Comparison Case 6 describe example embodiments of a lithium secondary battery comprising electrodes. *See* Ex. 1005, ¶27 (“Positive electrode preparation”), ¶28 (“Negative electrode preparation”), ¶29 (“Lithium secondary battery preparation: making the positive electrode, the negative electrode, and the separator prepared above into a cell; injecting the electrolyte obtained in Step (1); and performing formation and other processes to complete a lithium secondary battery.”).

c. [13.b]: “an electrolyte comprising”

184. As discussed in Section XI.A.1 above, in my opinion, Hong discloses an electrochemical device that further comprises an electrolyte. Hong states that the “[t]he purpose of the present invention is achieved through the following technical

solution: an electrolyte. . .” Ex. 1005, ¶¶6-7. Hong discloses example embodiments of an electrolyte in Embodiments 2, 18, 25, and Comparison Case 6. Ex. 1005, ¶¶34-35.

d. [13.c]: “a dinitrile compound”

185. As discussed in Section XI.A.1 above, in my opinion, Hong discloses an electrolyte that comprises a dinitrile compound. I note that the ’363 patent describes a “dinitrile compound” as “a compound comprising two cyano groups.” Ex. 1001, 1:39-41.

186. As discussed in Section XI.A.1 above, Hong discloses that the electrolyte may comprise one or more of the dinitrile compounds succinonitrile (SN), adiponitrile (ADN), and ethylene glycol bis(propionitrile) ether (DENE), each of which comprises two cyano groups. Ex. 1005, ¶15. Hong’s Embodiments 2, 18, 25, and Comparison Case 6 disclose example embodiments of an electrolyte comprising the dinitrile compounds succinonitrile (SN), adiponitrile (ADN), and ethylene glycol bis(propionitrile) ether (DENE). Ex. 1005, ¶¶34-35.

e. [13.d]: “a trinitrile compound, and”

187. As discussed in Section XI.A.1 above, in my opinion, Hong discloses electrolytes further comprising a trinitrile compound. I note that the ’363 patent describes a “trinitrile compound” as “a compound comprising three cyano groups.” Ex. 1001, 1:41-42.

188. As discussed in Section XI.A.1 above, Hong teaches tricyanophosphite and tricyanophosphate compounds as functional compounds to be added to the electrolyte. *See* Ex. 1005, ¶¶7-9, 19-24. Each of the tricyanophosphite and tricyanophosphate compounds is a trinitrile compound comprising three cyano groups.

189. As discussed in Section XI.A.1 above, Hong also teaches that the electrolyte may comprise the trinitrile compound 1,3,6-hexane tricarbonitrile (HTCN). *See* Ex. 1005, ¶15 (“The additive is a common additive used in the art, for example, the additive is . . . 1,3,6-hexane tricarbonitrile (HTCN). . . .”); *see also* ¶¶34-35. 1,3,6-hexane tricarbonitrile is a trinitrile compound.

190. As discussed in Section XI.A.1 above, Embodiments 2 and 18 contain the tricyanophosphite Compound I₁. Ex. 1005, ¶¶34-35. Embodiment 25 contains the tricyanophosphate Compound II₆, as well as 1,3,6-hexane tricarbonitrile (HTCN). Ex. 1005, ¶35. Comparison Case 6 contains the trinitrile compound 1,3,6-hexane tricarbonitrile (HTCN). Ex. 1005, ¶35.

f. [13.e]: “propyl propionate,”

191. As discussed in Section XI.A.1 above, in my opinion, Hong discloses an electrolyte that further comprises propyl propionate. Hong discloses that the organic solvent may include propyl propionate and recites it among a list of preferred solvent components. Ex. 1005, ¶¶13-14. Embodiments 2, 18, 25, and Comparison

Case 6 of Hong contain propyl propionate (PP) as a co-solvent in the electrolyte. Ex. 1005, ¶¶34-35.

- g. [13.f]: “wherein, based on a total weight of the electrolyte, a weight percentage of the dinitrile compound is X and a weight percentage of the trinitrile compound is Y, where X and Y meet conditions represented by Formula (1). . . about 2 wt % $\leq$ (X+Y) $\leq$ about 11 wt % (1);”**

192. As discussed in Section XI.A.1 above, in my opinion, Hong discloses an electrolyte that satisfies Formula (1).

193. As discussed in Section XI.A.1 above, Embodiments 2, 18, 25, and Comparison Case 6 contain 2 wt % of the dinitrile compound adiponitrile (ADN), 1 wt % of the dinitrile compound succinonitrile (SN), and 1 wt % of the dinitrile compound ethylene glycol bis(propionitrile) ether (DENE). Ex. 1005, ¶¶34-35. The total weight percentage of the dinitrile compounds for those examples is 4 wt % (i.e., $X = 4$ wt %).

194. As discussed in Section XI.A.1 above, Embodiment 2 contains 0.8 wt % of the trinitrile Compound I₁. Ex. 1005, ¶34. Thus, for Embodiment 2, $Y = 0.8$ wt %.

195. As discussed in Section XI.A.1 above, Embodiment 18 contains 5 wt % of the trinitrile Compound I₁. Ex. 1005, ¶35. Thus, for Embodiment 18, $Y = 5$ wt %.

196. As discussed in Section XI.A.1 above, Embodiment 25 contains 1.5 wt % of the trinitrile Compound II₆ and 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. The total weight percentage of the dinitrile compounds for Embodiment 25 is 2.0 wt % (i.e., $Y = 2.0$ wt %).

197. As discussed in Section XI.A.1 above, Comparison Case 6 contains 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. Thus, for Comparison Case 6, $Y = 0.5$ wt %.

198. As discussed in Section XI.A.1 above, in my opinion, Hong discloses electrolytes satisfying Formula (1). Embodiment 2 discloses an electrolyte wherein $X+Y = 4 + 0.8 = 4.8$ wt %. Embodiment 18 discloses an electrolyte wherein $X+Y = 4 + 5 = 9$ wt %. Embodiment 25 discloses an electrolyte wherein $X+Y = 4 + 2.0 = 6.0$ wt %. Comparison Case 6 discloses an electrolyte wherein $X+Y = 4 + 0.5 = 4.5$ wt %.

199. Table 16 below summarizes the weight proportion of dinitrile compounds and trinitrile compounds and the values for Formula (1) in Embodiments 2, 18, 25, and Comparison Case 6. *See* § XI.A.1, *supra*.

Example	Dinitrile wt % (X)	Trinitrile wt % (Y)	Formula (1) (X + Y)
Embodiment 2	4	0.8	4.8
Embodiment 18	4	5	9

Embodiment 25	4	2.0	6.0
Comparison Case 6	4	0.5	4.5

Table 16: *Calculation of Formula (1) for Hong's Embodiments 2, 18, 25, and Comparison Case 6*

h. [13.g]: “and Formula (2). . . about $0.1 \leq (X/Y) \leq$ about 8 (2),”

200. As discussed in Section XI.A.1 above, in my opinion, Hong discloses electrolytes satisfying Formula (2).

201. As discussed in Section XI.A.1 above, Embodiments 2, 18, 25, and Comparison Case 6 contain 2 wt % of the dinitrile compound adiponitrile (ADN), 1 wt % of the dinitrile compound succinonitrile (SN), and 1 wt % of the dinitrile compound ethylene glycol bis(propionitrile) ether (DENE). Ex. 1005, ¶¶34-35. The total weight percentage of the dinitrile compounds for those examples is 4 wt % (i.e., $X = 4$ wt %).

202. As discussed in Section XI.A.1 above, Embodiment 2 contains 0.8 wt % of the trinitrile Compound I₁. Ex. 1005, ¶34. Thus, for Embodiment 2, $Y = 0.8$ wt %.

203. As discussed in Section XI.A.1 above, Embodiment 18 contains 5 wt % of the trinitrile Compound I₁. Ex. 1005, ¶35. Thus, for Embodiment 18, $Y = 5$ wt %.

204. As discussed in Section XI.A.1 above, Embodiment 25 contains 1.5 wt % of the trinitrile Compound II₆ and 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. The total weight percentage of the dinitrile compounds for Embodiment 25 is 2.0 wt % (i.e., $Y = 2.0$ wt %).

205. As discussed in Section XI.A.1 above, Comparison Case 6 contains 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. Thus, for Comparison Case 6, $Y = 0.5$ wt %.

206. As discussed in Section XI.A.1 above, in my opinion, Hong discloses electrolytes satisfying Formula (2). Embodiment 2 discloses an electrolyte wherein $X/Y = 4/0.8 = 5$. Embodiment 18 discloses an electrolyte wherein $X/Y = 4/5 = 0.8$. Embodiment 25 discloses an electrolyte wherein $X/Y = 4/2.0 = 2.0$. Comparison Case 6 discloses an electrolyte wherein $X/Y = 4/0.5 = 8.0$.

207. Table 17 summarizes the weight proportion of dinitrile compounds and trinitrile compounds and calculation of Formula (2) for Embodiments 2, 18, 25, and Comparison Case 6. *See* § XI.A.1, *supra*.

Example	Dinitrile wt % (X)	Trinitrile wt % (Y)	Formula (2) (X/Y)
Embodiment 2	4	0.8	5.0
Embodiment 18	4	5	0.8
Embodiment 25	4	2.0	2.0

Comparison Case 6	4	0.5	8.0
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***Table 17:** Calculation of Formula (2) for Hong’s
Embodiments 2, 18, 25, and Comparison Case 6*

9. Claim 16

208. In my opinion, Hong anticipates claim 16.

a. [16pre]: “An electronic device, comprising”

209. In my opinion, Hong discloses an electronic device. Hong states that “[l]ithium-ion secondary batteries. . . have been widely used in consumer electronic, energy storage, and power products.” Ex. 1005, ¶2. Embodiments 2, 18, 25, and Comparison Case 6 describe example embodiments of a lithium secondary battery on which charge-discharge tests were performed, including a high-temperature cycle test and a high-temperature storage performance test. Ex. 1005, ¶31. In both tests, the lithium secondary battery is connected to a battery tester that applies an electrical load to the battery using a load bank. The tester then measures the voltage or current across time to create a charge-discharge curve. Both tests thus would have involved charging and discharging the battery by connecting it to an electronic device.

b. [16.a]: “an electrochemical device”

210. As discussed in Section XI.A.8 above, in my opinion, Hong discloses an electronic device comprising an electrochemical device.

211. As discussed in Section XI.A.8 above, Hong states that its invention “belongs to the field of lithium secondary batteries, and in particular to an electrolyte and a secondary battery containing the electrolyte.” Ex. 1005, ¶1. A person of ordinary skill in the art would understand that a lithium secondary battery such as the one described in Hong is an electrochemical device.

212. As discussed in Section XI.A.8 above, Embodiments 2, 18, 25, and Comparison Case 6 describe example embodiments of a lithium secondary battery containing the described electrolyte. *See* Ex. 1005, ¶25 (“Below are the steps for the manufacturing and performance testing of the lithium secondary battery according to embodiments of the present invention.”).

c. [16.b]: “that includes electrodes and”

213. As discussed in Section XI.A.8 above, in my opinion, Hong discloses an electrochemical device that includes electrodes. Hong states that “[t]he present invention also relates to a lithium secondary battery containing the aforementioned electrolyte, the lithium secondary battery comprising a positive *electrode* containing a positive electrode active material, a negative *electrode* containing a negative electrode active material, a separator, and the aforementioned electrolyte.” Ex. 1005, ¶16 (emphasis added).

214. As discussed in Section XI.A.8 above, Embodiments 2, 18, 25, and Comparison Case 6 describe example embodiments of a lithium secondary battery

comprising electrodes. *See* Ex. 1005, ¶27 (“Positive electrode preparation”), ¶28 (“Negative electrode preparation”), ¶29 (“Lithium secondary battery preparation: making the positive electrode, the negative electrode, and the separator prepared above into a cell; injecting the electrolyte obtained in Step (1); and performing formation and other processes to complete a lithium secondary battery.”).

d. [16.c]: “an electrolyte comprising”

215. As discussed in Sections XI.A.1 and XI.A.8 above, in my opinion, Hong discloses an electrochemical device that further comprises an electrolyte. Hong states that the “[t]he purpose of the invention is achieved through the following technical solution: an electrolyte. . .” Ex. 1005, ¶¶6-7. Hong discloses example embodiments of an electrolyte in Embodiments 2, 18, 25, and Comparison Case 6. Ex. 1005, ¶¶34-35.

e. [16.d]: “a dinitrile compound”

216. As discussed in Sections XI.A.1 and XI.A.8 above, in my opinion, Hong discloses electrolytes comprising a dinitrile compound. I note that the ’363 patent describes a “dinitrile compound” as “a compound comprising two cyano groups.” Ex. 1001, 1:39-41.

217. As discussed in Sections XI.A.1 and XI.A.8 above, Hong discloses that the electrolyte may comprise one or more of the dinitrile compounds succinonitrile (SN), adiponitrile (ADN), and ethylene glycol bis(propionitrile) ether (DENE), each

of which comprises two cyano groups. Ex. 1005, ¶15. Hong's Embodiments 2, 18, 25, and Comparison Case 6 disclose example embodiments of an electrolyte comprising the dinitrile compounds succinonitrile (SN), adiponitrile (ADN), and ethylene glycol bis(propionitrile) ether (DENE). Ex. 1005, ¶¶34-35.

f. [16.e]: “a trinitrile compound, and”

218. As discussed in Sections XI.A.1 and XI.A.8 above, in my opinion, Hong discloses electrolytes further comprising a trinitrile compound. I note that the '363 patent describes a “trinitrile compound” as “a compound comprising three cyano groups.” Ex. 1001, 1:41-42.

219. As discussed in Sections XI.A.1 and XI.A.8 above, Hong teaches tricyanophosphite and tricyanophosphate compounds as functional compounds to be added to the electrolyte. *See* Ex. 1005, ¶¶7-9, 19-24. Each of the tricyanophosphite and tricyanophosphate compounds is a trinitrile compound comprising three cyano groups.

220. As discussed in Sections XI.A.1 and XI.A.8 above, Hong also teaches that the electrolyte may comprise the trinitrile compound 1,3,6-hexane tricarbonitrile. *See* Ex. 1005, ¶15 (“The additive is a common additive used in the art, for example, the additive is. . . 1,3,6-hexane tricarbonitrile (HTCN). . .”).

221. As discussed in Sections XI.A.1 and XI.A.8 above, Embodiments 2 and 18 contain the tricyanophosphite Compound I₁. Embodiment 25 contains the

tricyanophosphate Compound II₆, as well as 1,3,6-hexane tricarbonitrile (HTCN). Comparison Case 6 contains the trinitrile compound 1,3,6-hexane tricarbonitrile (HTCN).

g. [16.f]: “propyl propionate,”

222. As discussed in Sections XI.A.1 and XI.A.8 above, in my opinion, Hong discloses an electrolyte that further comprises propyl propionate. Hong discloses that the organic solvent may include propyl propionate and recites it among a list of preferred solvent components. Ex. 1005, ¶¶13-14. Embodiments 2, 18, 25, and Comparison Case 6 of Hong contain propyl propionate (PP) as a co-solvent in the electrolyte. Ex. 1005, ¶¶34-35.

h. [16.g]: “wherein, based on a total weight of the electrolyte, a weight percentage of the dinitrile compound is X and a weight percentage of the trinitrile compound is Y, where X and Y meet conditions represented by Formula (1). . . about 2 wt % ≤ (X+Y) ≤ about 11 wt % (1);”

223. As discussed in Sections XI.A.1 and XI.A.8 above, in my opinion, Hong discloses an electrolyte that satisfies Formula (1).

224. As discussed in Sections XI.A.1 and XI.A.8 above, Embodiments 2, 18, 25, and Comparison Case 6 contain 2 wt % of the dinitrile compound adiponitrile (ADN), 1 wt % of the dinitrile compound succinonitrile (SN), and 1 wt % of the dinitrile compound ethylene glycol bis(propionitrile) ether (DENE). Ex. 1005, ¶¶34-

35. The total weight percentage of the dinitrile compounds for those examples is 4 wt % (i.e., $X = 4$ wt %).

225. As discussed in Sections XI.A.1 and XI.A.8 above, Embodiment 2 contains 0.8 wt % of the trinitrile Compound I_1 . Ex. 1005, ¶34. Thus, for Embodiment 2, $Y = 0.8$ wt %.

226. As discussed in Sections XI.A.1 and XI.A.8 above, Embodiment 18 contains 5 wt % of the trinitrile Compound I_1 . Ex. 1005, ¶35. Thus, for Embodiment 18, $Y = 5$ wt %.

227. As discussed in Sections XI.A.1 and XI.A.8 above, Embodiment 25 contains 1.5 wt % of the trinitrile Compound II_6 and 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. The total weight percentage of the dinitrile compounds for Embodiment 25 is 2.0 wt % (i.e., $Y = 2.0$ wt %).

228. As discussed in Sections XI.A.1 and XI.A.8 above, Comparison Case 6 contains 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. Thus, for Comparison Case 6, $Y = 0.5$ wt %.

229. As discussed in Sections XI.A.1 and XI.A.8 above, in my opinion, Hong discloses electrolytes satisfying Formula (1). Embodiment 2 discloses an electrolyte wherein $X+Y = 4 + 0.8 = 4.8$ wt %. Embodiment 18 discloses an electrolyte wherein $X+Y = 4 + 5 = 9$ wt %. Embodiment 25 discloses an electrolyte

wherein $X+Y = 4 + 2.0 = 6.0$ wt %. Comparison Case 6 discloses an electrolyte wherein $X+Y = 4 + 0.5 = 4.5$ wt %.

230. Table 18 below summarizes the weight proportion of dinitrile compounds and trinitrile compounds and the values for Formula (1) in Embodiments 2, 18, 25, and Comparison Case 6. *See* §§ XI.A.1, XI.A.8, *supra*.

Example	Dinitrile wt % (X)	Trinitrile wt % (Y)	Formula (1) (X + Y)
Embodiment 2	4	0.8	4.8
Embodiment 18	4	5	9
Embodiment 25	4	2.0	6.0
Comparison Case 6	4	0.5	4.5

Table 18: *Calculation of Formula (1) for Hong's Embodiments 2, 18, 25, and Comparison Case 6*

- i. [16.h]: “and Formula (2). . . about $0.1 \leq (X/Y) \leq$ about 8 (2),”

231. As discussed in Sections XI.A.1 and XI.A.8 above, in my opinion, Hong discloses an electrolyte that satisfies Formula (2).

232. As discussed in Sections XI.A.1 and XI.A.8 above, Embodiments 2, 18, 25, and Comparison Case 6 contain 2 wt % of the dinitrile compound adiponitrile (ADN), 1 wt % of the dinitrile compound succinonitrile (SN), and 1 wt % of the dinitrile compound ethylene glycol bis(propionitrile) ether (DENE). Ex. 1005, ¶¶34-

35. The total weight percentage of the dinitrile compounds for those examples is 4 wt % (i.e., $X = 4$ wt %).

233. As discussed in Sections XI.A.1 and XI.A.8 above, Embodiment 2 contains 0.8 wt % of the trinitrile Compound I₁. Ex. 1005, ¶34. Thus, for Embodiment 2, $Y = 0.8$ wt %.

234. As discussed in Sections XI.A.1 and XI.A.8 above, Embodiment 18 contains 5 wt % of the trinitrile Compound I₁. Ex. 1005, ¶35. Thus, for Embodiment 18, $Y = 5$ wt %.

235. As discussed in Sections XI.A.1 and XI.A.8 above, Embodiment 25 contains 1.5 wt % of the trinitrile Compound II₆ and 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. The total weight percentage of the dinitrile compounds for Embodiment 25 is 2.0 wt % (i.e., $Y = 2.0$ wt %).

236. As discussed in Sections XI.A.1 and XI.A.8 above, Comparison Case 6 contains 0.5 wt % of the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1005, ¶35. Thus, for Comparison Case 6, $Y = 0.5$ wt %.

237. As discussed in Sections XI.A.1 and XI.A.8 above, in my opinion, Hong discloses electrolytes satisfying Formula (2). Embodiment 2 discloses an electrolyte wherein $X/Y = 4/0.8 = 5$. Embodiment 18 discloses an electrolyte

wherein $X/Y = 4/5 = 0.8$. Embodiment 25 discloses an electrolyte wherein $X/Y = 4/2.0 = 2.0$. Comparison Case 6 discloses an electrolyte wherein $X/Y = 4/0.5 = 8.0$.

238. Table 19 summarizes the weight proportion of dinitrile compounds and trinitrile compounds and calculation of Formula (2) for Embodiments 2, 18, 25, and Comparison Case 6. *See* §§ XI.A.1, XI.A.8, *supra*.

Example	Dinitrile wt % (X)	Trinitrile wt % (Y)	Formula (2) (X/Y)
Embodiment 2	4	0.8	5.0
Embodiment 18	4	5	0.8
Embodiment 25	4	2.0	2.0
Comparison Case 6	4	0.5	8.0

***Table 19: Calculation of Formula (2) for Hong's
Embodiments 2, 18, 25, and Comparison Case 6***

B. Claims 7-9 of the '363 Patent Are Obvious over the Combination of Hong and Zhuang

239. In my opinion, for the reasons discussed below, the combination of Hong and Zhuang renders obvious claims 7-9 of the '363 patent.

1. Motivation to Combine Hong and Zhuang

240. In my opinion, a person of ordinary skill in the art would have been motivated to modify the electrolyte of Hong to incorporate a fluoroether of Zhuang. It is my further opinion that a person of ordinary skill in the art would have had a

reasonable expectation of success in modifying the electrolyte of Hong to incorporate a fluoroether of Zhuang.

241. Hong discloses electrolytes, including exemplary Embodiments 2, 18, and 25, that contain the carboxylate compound propyl propionate (PP), as well as ethylene glycol bis(propionitrile) ether (DENE), which is a dinitrile compound comprising an ether bond. Ex. 1005, ¶¶34-35. Hong aims to improve the high-temperature performance of the battery. Ex. 1005, ¶¶18, 31, 41-42.

242. Zhuang discloses that the combination of a fluoroether compound, a carboxylate compound such as propyl propionate (PP), and a dinitrile compound comprising an ether bond such as DENE can achieve synergistic benefits, including an improvement in high-temperature battery performance. In particular, Zhuang states “the electrolyte comprising carboxylate compounds, fluoroether compounds and dinitrile compounds comprising ether bonds, after being applied to the lithium-ion battery, is capable of improving the high temperature storage performance, high temperature cycle life performance and rate performance of the lithium-ion battery.” Ex. 1006, ¶5; *see also* ¶86.

243. Zhuang discloses that fluoroether compounds having the structures shown in Figure 27 achieve its objectives.

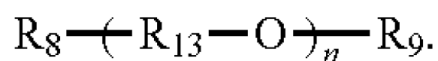
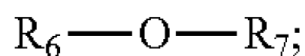


Figure 27: *General Structure of Preferred Fluoroethers in Zhuang*

R_6 and R_7 can be a fluoroalkyl, a fluoroalkenyl, or a fluoroaryl. Ex. 1006, ¶44. R_8 and R_9 can be an alkyl, an alkenyl, an aryl, a fluoroalkyl, a fluoroalkenyl, or a fluoroaryl. Ex. 1006, ¶45. R_{13} can be a fluoroalkylene, a fluoroalkenylene, or a fluoroarylene. Ex. 1006, ¶45. n is an integer between 2-10. Ex. 1006, ¶45.

244. Zhuang further discloses Compounds B1-B7, which are specific embodiments of fluoroethers according to these structures, as shown in Figure 28 below. Ex. 1006, ¶105, 72.

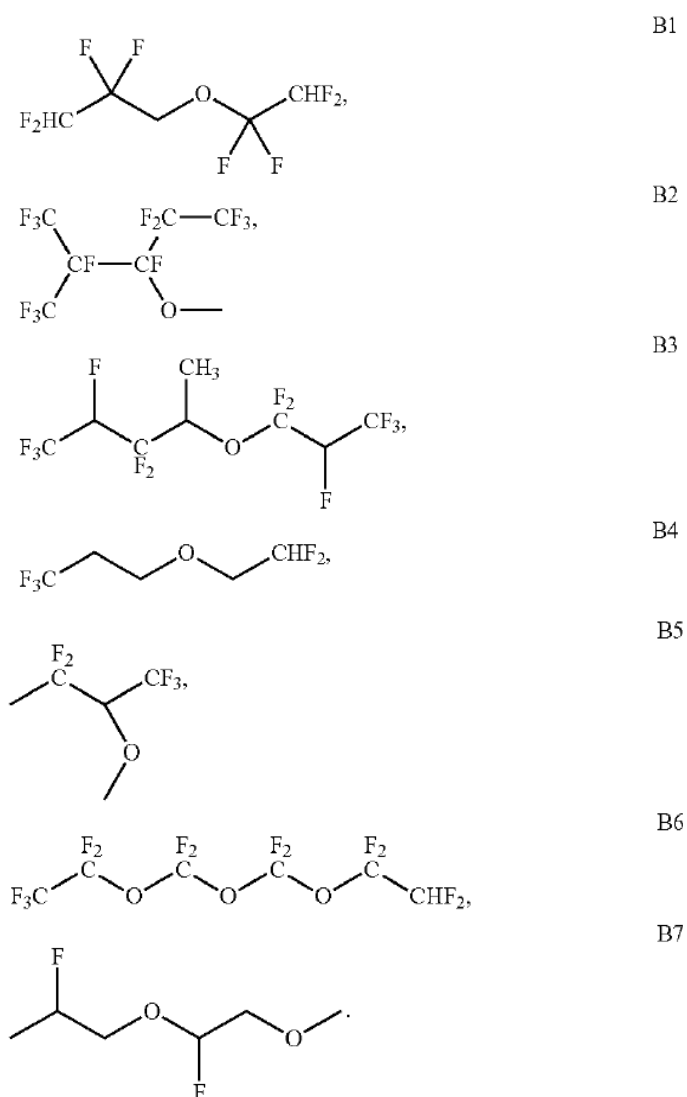


Figure 28: Structures of Exemplary Fluoroether Compounds B1-B7 in Zhuang

245. Zhuang demonstrates the efficacy of Compounds B1-B7 in its examples. In particular, Zhuang discloses that electrolytes comprising a carboxylate compound, one or more of Compounds B1-B7, and a dinitrile compound comprising an ether bond demonstrated improved properties relative to electrolytes lacking at least one of those three components. Ex. 1006, ¶¶126-129. These improved properties included faster anode wetting time; reduced battery thickness expansion

at high temperatures; improved battery capacity retention at high temperatures; reduced DC internal resistance; and improved discharge capacity retention rate for both regular- and irregular-shaped batteries. Ex. 1006, ¶¶143 (wetting time), 144-145 (thickness expansion rate and capacity retention rate at high temperature), 146 (DC internal resistance and capacity retention rate); *infra.*, §§ XI.B.1.a-XI.B.1.d. These are standard measures of battery performance that a person of ordinary skill in the art would have been motivated to improve. Indeed, Hong explicitly aims to reduce battery thickness expansion at high temperatures and improve battery capacity retention at high temperatures. *See* Ex. 1005, ¶43 (“[A] tricyanophosphite compound or a tricyanophosphate compound can effectively improve the battery’s cycling performance, *significantly increase the battery’s capacity retention rate after storage at a high temperature, suppress thickness expansion*, and mitigate lithium precipitation during low-temperature charging.”) (emphasis added); *see also* ¶¶30-31, 39-42.

246. In my opinion, a person of ordinary skill in the art would have been motivated to modify the electrolyte of Hong to incorporate a fluoroether of Zhuang in order to achieve the synergistic benefits that Zhuang teaches from the combination of a fluoroether compound, a carboxylate compound, and a dinitrile compound comprising an ether bond. Moreover, in my opinion, a person of ordinary skill in the

art would have had a reasonable expectation of success in modifying the electrolyte of Hong to incorporate a fluoroether of Zhuang.

247. Zhuang explains that the combination of carboxylate compounds, fluoroether compounds, and dinitrile compounds comprising ether bonds enables the beneficial properties of the electrolyte. Ex. 1006, ¶5. Embodiments 2, 18, and 25 of Hong comprise the carboxylate compound propyl propionate and the dinitrile compound comprising an ether bond DENE. Ex. 1005, ¶¶34-35. Zhuang discloses that the electrolyte may contain propyl propionate as the carboxylate compound and Compound C1 as the dinitrile compound comprising an ether bond. Ex. 1006, ¶¶40, 106. The structure of Compound C1 closely resembles that of DENE, as shown in Figure 29 below.

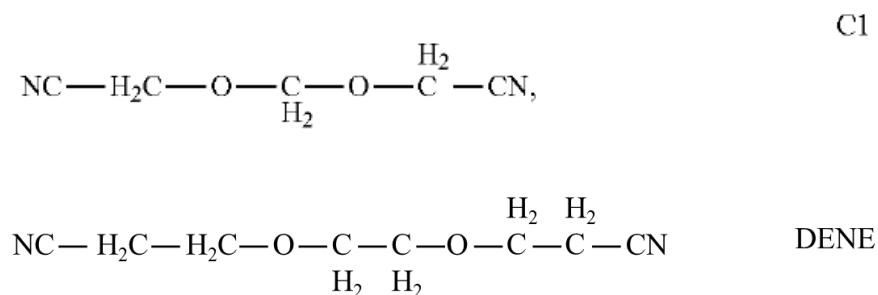


Figure 29: Structures of Compound C1 and DENE

248. Compound C1 contains one extra CH₂ between each cyano group and the oxygen atom closest to it, as well as between the oxygen atoms. In the examples, Zhuang uses Compound C1 as the dinitrile compound comprising an ether bond in the majority of the exemplary electrolytes. Ex. 1006, ¶126.

249. Zhuang and Hong overlap with respect to other components of the lithium-ion battery as well. Zhuang discloses that the electrolyte may contain one or more of fluoroethylene carbonate (FEC) and vinyl ethylene carbonate (VEC). Ex. 1006, ¶¶87, 107. Embodiments 2, 18, and 25 of Hong contain fluoroethylene carbonate. Ex. 1005, ¶¶34-35. Embodiments 2 and 18 of Hong also contain vinyl ethylene carbonate. Ex. 1005, ¶¶34-35.

250. Zhuang further discloses that the electrolyte may contain lithium hexafluorophosphate (LiPF_6) as the lithium salt. Ex. 1006, ¶¶93, 108, 110. Embodiments 2, 18, and 25 of Hong contain LiPF_6 as a lithium salt. Ex. 1005, ¶¶34-35.

251. Moreover, Hong discloses a method of preparing an electrolyte. Ex. 1005, ¶26. A person of ordinary skill in the art would have understood how to modify Hong's electrolyte preparation method to produce an electrolyte further comprising a fluoroether of Zhuang. Further, claims 7-9 of the '363 patent do not have an efficacy requirement, and it is rare that an additive would eliminate the functionality of a given electrolyte. Thus, in my opinion, a person of ordinary skill in the art would have had a reasonable expectation of success in producing a functional electrolyte by modifying the electrolyte disclosed in Hong to incorporate a fluoroether of Zhuang.

a. Preparation of Exemplary Electrolytes in Zhuang

252. Zhuang states that exemplary Electrolytes 1-17 were prepared by homogenously mixing the EC and DEC to form a non-aqueous organic solvent; dissolving the lithium salts in the organic solvent; adding carboxylic ester compound, fluoro-ether compound, dinitrile compounds having ether bonds, other additives and wetting additive into the organic solvent; and mixing them homogeneously to obtain the electrolyte, wherein the concentration of the lithium salts was 1 mol/L, and the weight ratio of EC and DEC was EC: DEC=3:7. Ex. 1006, ¶¶117-119. Zhuang used one or more of the following carboxylic ester compounds as Organic Solvent A: A1 (methyl acetate), A2 (propyl acetate), A3 (1-propylacetate), A4 (-cyanopropyl acetate), A5 (1,4-butyrolactone), and A6 (1,5-valerolactone). Ex. 1006, ¶¶103-104. Zhuang used one or more of compounds B1-B7 as the fluoroether compound. Ex. 1006, ¶105. The structures of compounds B1-B7 are shown in Figure 28 above. Zhuang also used LiPF_6 as the lithium salt. Ex. 1006, ¶¶108, 110.

253. For the dinitrile compound comprising an ether bond, Zhuang used compounds C1-C4, the structures of which are shown in Figure 30 below.

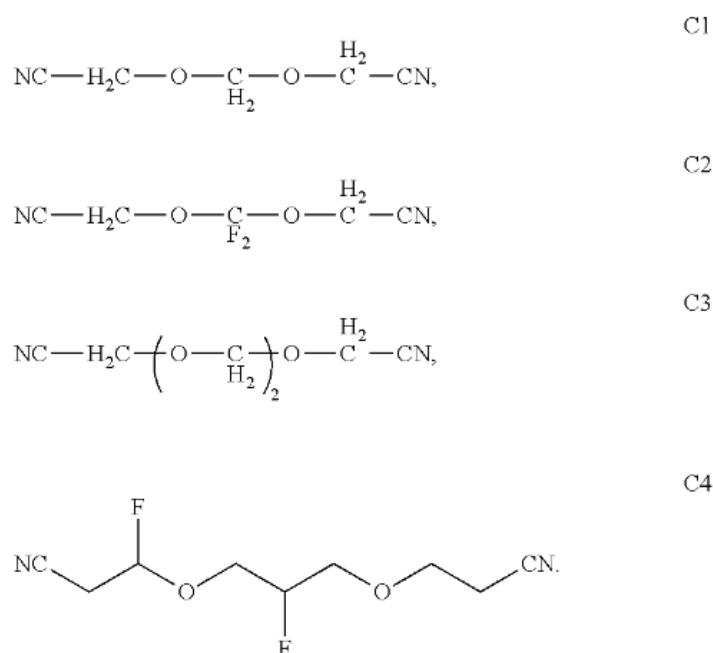


Figure 30: Structure of Dinitrile Compounds Comprising an Ether Bond in Zhuang's Exemplary Electrolytes

254. Certain electrolytes contained additional additives, including one or more of vinylene carbonate (VC), propylene sulfite (PS), fluoroethylene carbonate (FEC) and/or wetting additives D1 and D2. Ex. 1006, ¶¶90, 107, 109.

255. The exemplary electrolytes had the composition shown in Figure 31 below. Ex. 1006, ¶126.

Battery	Battery	Electrolyte	Organic Solvent A		Additive B		Additive C		Other additive	Additive D
No.	No.	No.	Type	Dosage	Type	Dosage	Type	Dosage	Type and dosage	Type and dosage
Battery1	S1	Electrolyte1	A1	20%	B1	2%	C1	0.10%	-, 0%	-, 0%
Battery2	S2	Electrolyte2	A1	20%	B1	2%	C1	1%	-, 0%	-, 0%
Battery3	S3	Electrolyte3	A1	20%	B1	2%	C1	5%	VC + PS, 5%	-, 0%
Battery4	S4	Electrolyte4	A1	20%	B1	2%	C1	10%	-, 0%	-, 0%
Battery5	S5	Electrolyte5	A3	20%	B1	1%	C1	1%	-, 0%	-, 0%
Battery6	S6	Electrolyte6	A4	20%	B1	5%	C1	1%	-, 0%	-, 0%
Battery7	S7	Electrolyte7	A1	20%	B1	10%	C1	1%	-, 0%	-, 0%
Battery8	S8	Electrolyte8	A1	20%	B2	2%	C1	1%	VC + PS, 5%	-, 0%
Battery9	S9	Electrolyte9	A1	20%	B2	2%	C1	1%	-, 0%	-, 0%
Battery10	S10	Electrolyte10	A1	20%	B2	2%	C2	1%	-, 0%	-, 0%
Battery11	S11	Electrolyte11	A2	20%	B2	2%	C2	1%	-, 0%	-, 0%
Battery12	S12	Electrolyte12	A5	20%	B5	2%	C2	1%	-, 0%	-, 0%
Battery13	S13	Electrolyte13	A1 + A2	20%	B1 + B4	2%	C2	1%	-, 0%	-, 0%
Battery14	S14	Electrolyte14	A1	25%	B6	3%	C3	2%	-, 0%	D1, 2%
Battery15	S15	Electrolyte15	A5	30%	B3	4%	C1	3%	VC + PS, 5%	-, 0%
Battery16	S16	Electrolyte16	A6	20%	B7	2%	C4	4%	VC + PS, 5%	D2, 5%
Battery17	S17	Electrolyte17	A5	30%	B1	5%	C1	2%	FEC + PS, 5%	-, 0%

Note:

in table 1, VC weight:PS weight = 2:3, FEC weight:PS weight = 2:3, A1 weight:A2 weight = 2:1, B1 weight:B4 weight = 1:1, and "-" represents no substance to be selected.

Figure 31: Compositions of Exemplary Electrolytes in Zhuang

256. Zhuang also discloses the preparation of comparative Electrolytes 1[#]-4[#], shown in Figure 32 below. Ex. 1006, ¶¶127-130.

Battery	Battery	Electrolyte	Organic Solvent A		Additive B		Additive C		Other additive	Additive D
No.	No.	No.	Type	Dosage	Type	Dosage	Type	Dosage	Type and dosage	Type and dosage
Battery 1 [#]	S1 [#]	Electrolyte 1 [#]	—	0%	—	0%	—	0%	-, 0%	-, 0%
Battery 2 [#]	S2 [#]	Electrolyte 2 [#]	A1	20%	—	0%	—	0%	VC + PS, 5%	-, 0%
Battery 3 [#]	S3 [#]	Electrolyte 3 [#]	A1	20%	B1	2%	—	0%	VC + PS, 5%	-, 0%
Battery 4 [#]	S4 [#]	Electrolyte 4 [#]	A1	20%	—	0%	C1	2%	VC + PS, 5%	-, 0%

Note:

in table 2, VC weight:PS weight = 2:3, and "-" represents no substance to be selected.

Figure 32: Compositions of Comparative Electrolytes in Zhuang

257. Zhuang discloses that both the exemplary electrolytes and the comparative electrolytes were injected into regular- and irregular-shaped batteries for testing. Ex. 1006, ¶¶120-129. The regular-shaped batteries (e.g., Battery1) were formed by laminating a normally slit cathode, a separator, and a normally slit anode; winding them to obtain a naked cell; putting the naked cell in the external package foil; and injecting the electrolyte. Ex. 1006, ¶¶120-122. The irregular-shaped batteries (e.g., Battery S1) were formed by slitting the cathode and anode into sheets of different sizes; laminating the cathode, separator, and anode to obtain a ladder-shape naked cell; putting the naked cell in the external package foil; and injecting the electrolyte. Ex. 1006, ¶¶120-124.

b. Zhuang's Fluoroethers Improve Wettability

258. To evaluate the wettability of the electrolyte, Zhuang tested the surface tension of the electrolyte at 25 °C through a surface tension meter; tested the wetting time by dropping the electrolyte on the surface of the anode sheet and then tested the disappearance time of the electrolyte, the results of which are shown in Figure 33. Ex. 1006, ¶¶131-132. The smaller the surface tension and the shorter the disappearance time, the better the wettability of the electrolyte. Ex. 1006, ¶¶131-132. As shown in Figure 33, Zhuang determined that electrolytes comprising a fluoroether compound, a dinitrile compound comprising an ether bond, and a carboxylic ester compound (Electrolytes 1-17) had relatively low surface tension

and short wetting time as compared with the electrolytes that lacked one or more of those components (Electrolytes 1[#]-4[#]). Ex. 1006, ¶143.

	Electrolyte No.	Surface tension mN/m	Wetting time/S
Exemplary Electrolytes	Electrolyte 1	23.1	55
	Electrolyte 2	16.6	50
	Electrolyte 3	15.5	44
	Electrolyte 4	19.3	55
	Electrolyte 5	18.9	52
	Electrolyte 6	18.5	51
	Electrolyte 7	17.8	45
	Electrolyte 8	13.6	42
	Electrolyte 9	17.9	54
	Electrolyte 10	21.7	57
	Electrolyte 11	22.8	52
	Electrolyte 12	18.3	49
	Electrolyte 13	20.6	55
	Electrolyte 14	18.9	52
	Electrolyte 15	14.5	43
	Electrolyte 16	12.1	38
Comparative Electrolytes	Electrolyte 17	13.3	40
	Electrolyte 1 [#]	80.6	130
	Electrolyte 2 [#]	45.6	74
	Electrolyte 3 [#]	40.5	70
	Electrolyte 4 [#]	42.9	68

Figure 33: Wettability of Exemplary Electrolytes in Zhuang

c. Zhuang's Fluoroethers Improve High-Temperature Storage Stability and Cycle Life

259. Zhuang discloses that high-temperature storage stability was tested by: statically keeping the battery for 30 minutes, charging it with constant currents at a rate of 0.5 C until the voltage reaches to 4.45V, and continuing charging it under constant voltage of 4.45V until the currents reach to 0.05 C; static keeping the battery for 5 minutes, then storing it at 60 °C. for 4 hours, and finally testing the thickness expansion rate of the battery. Ex. 1006, ¶¶133-134. The results of this testing are

shown in Figure 34 below. The thickness expansion rate of the battery was calculated through the following formula:

$$\text{thickness expansion rate} = [(\text{thickness after storage} - \text{thickness before storage}) / \text{thickness before storage}] \times 100\%.$$

Ex. 1006, ¶¶133-134.

260. To evaluate the high-temperature cycle life, Zhuang tested the batteries by: charging the battery with constant currents of 1 C at 45 °C until the voltage reached 4.45V, continuing the constant voltage charge until the current dropped below 0.05 C, and then discharging the battery with constant currents of 1 C until voltage reached to 3V, which at this time constitutes the initial primary; repeating the battery cycling according to the previous conditions multiple times; and calculating the capacity retention rate of the battery after 50 cycles, 100 cycles, 200 cycles, and 300 cycles, respectively. Ex. 1006, ¶¶135-136. Zhuang used the following formula to calculate the capacity retention rate after cycling:

$$\text{capacity retention rate} = (\text{discharge capacity} / \text{discharge capacity of the initial cycle}) \times 100\%.$$

Ex. 1006, ¶136.

261. As shown in Figure 34, Zhuang determined that the batteries comprising a fluoroether compound, a dinitrile compound comprising an ether bond,

and a carboxylic ester compound (Batteries 1-17 and S1-S17) had relatively low thickness expansion rate and relatively high capacity retention rate when tested after storing the batteries in full charge for 4 hours at 45 °C and cycle life the batteries in 50, 100, 200 and 300 times as compared with the batteries that lacked one or more of those components (Batteries 1[#]-4[#] and S1[#]-S4[#]). Ex. 1006, ¶¶143-144; *see also* ¶145. In Figure 34, the mark ① above the thickness expansion rate and capacity retention rate data represents the data related to regular-shaped batteries 1-17 and 1[#]-4[#], and ② represents the data related to irregular-shaped batteries S1-S17 and S1[#]-S4[#]. Ex. 1006, ¶137.

		Thickness expansion		Capacity retention rate after n times of circulation at 45° C. (%)							
		rate/%		50 times		100 times		200 times		300 times	
①	②	①	②	①	②	①	②	①	②	①	②
Battery1	S1	6.3	5.3	95.5	94.3	93.6	92.4	90.7	89.5	88.3	87.1
Battery2	S2	5.8	4.8	95.7	94.8	93.5	92.6	90.6	89.7	88.2	87.3
Battery3	S3	5.7	4.7	95.9	95.1	94	93.2	91.1	90.3	88.8	88
Battery4	S4	5	4	94.2	93.4	91.9	91.1	88.6	87.8	86.9	86.1
Battery5	S5	6.8	5.8	93.2	92.4	91.1	90.3	88.2	87.4	85.9	85.1
Battery6	S6	7.4	6.4	93.3	92.5	91.6	90.8	88.2	87.4	85.9	85.1
Battery7	S7	6.8	5.8	95.9	95.1	94.5	93.7	91.3	90.5	89.2	88.4
Battery8	S8	5.6	4.6	96.8	96.3	95.3	94.5	93.8	92.1	91.8	90.5

Battery9	S9	6.5	5.5	93.3	92.5	90.5	89.7	87.9	87.1	84.2	83.4
Battery10	S10	6.3	5.3	91.9	91.1	89.1	88.3	86.3	85.5	83.6	82.8
Battery11	S11	5.9	4.9	94.6	93.8	93.3	92.5	90.4	89.6	87.6	86.8
Battery12	S12	5.3	4.3	95	94.2	92.9	92.1	89.9	89.1	88.3	87.5
Battery13	S13	6.8	5.8	94.8	94	93	92.2	90.4	89.6	88.2	87.4
Battery14	S14	6.5	5.5	95.1	94.5	93.8	92.8	91.1	90.7	89.4	88.3
Battery15	S15	6.1	5.2	95.7	95.1	94.2	-93.6	92.8	91.1	90.5	89.8
Battery16	S16	5.1	4.2	97.9	96.8	95.4	94.7	93.9	92.6	91.6	90.9
Battery17	S17	5.8	4.6	96.9	96.4	95.1	94.2	93.2	91.8	91.1	90.3
Battery1 [#]	S1 [#]	23.5	22	91.7	81.4	86.9	76.6	81.3	71	76.5	66.2
Battery2 [#]	S2 [#]	40.2	43.2	90.5	80.2	84.5	74.2	77.8	67.5	71.4	61.1
Battery3 [#]	S3 [#]	16.5	15.5	92	81.7	86	75.7	79.3	69	72.9	62.6
Battery4 [#]	S4 [#]	23.2	22.9	90.6	80.3	84.6	74.3	77.9	67.6	71.5	61.2

Figure 34: High-Temperature Storage Stability and Cycle Life of Batteries in Zhuang

d. Zhuang's Fluoroethers Reduce DC Internal Resistance and Improve the Capacity Retention Rate

262. Zhuang tested the DC internal resistance and discharge capacity retention rate by: charging the battery with constant currents of 1 C at 25 °C until the voltage reached 4.45V, then charging it at constant voltage of 4.45V until the current was <0.05 C, leaving the battery alone for 5 minutes, discharging the battery with constant currents of 1 C until the voltage reached 3V, recording the actual discharge capacity, adjusting the actual capacity of the battery to be 50% of the full charge capacity, discharging battery continuously with the currents of 0.3 C for 10 seconds, and dividing the difference between the voltage before discharge and the voltage when discharge terminates by the currents to obtain the DC internal resistance (DCIR) (adopting the average value of the test results of 15 batteries). Ex. 1006, ¶139.

263. Zhuang tested the discharge capacity retention rate by: discharging the battery with the constant currents of 0.5 C until the voltage reached 3.0V, leaving the battery alone for 5 minutes, charging the battery with the constant currents of 0.5 C until the voltage reached 4.45V, continuing charging the battery with the constant voltage until the currents reached 0.05 C, static keeping the battery for 5 minutes, and then discharging the battery with constant currents of respective 0.2 C, 0.5 C, 1 C, 2 C and 3 C until the voltage reached 3.0V, recording the discharge capacity under the conditions of 0.2 C, 0.5 C, 1 C, 2 C, and 3 C, and calculating the discharge capacity retention rate at different rates based on the discharge capacity under 0.2 C (adopting the average value of the test results of 15 batteries). Ex. 1006, ¶141.

264. The results of the DC internal resistance and discharge capacity retention rate tests are shown in Figure 35 below. As shown in Figure 35, Zhuang determined that the batteries comprising a fluoroether compound, a dinitrile compound comprising an ether bond, and a carboxylic ester compound (Batteries 1-17 and S1-S17) had relatively low DC internal resistance and relatively high capacity retention rate obtained by both the DC internal resistance test and the respective test at different rates of 0.2 C, 0.5 C, 1 C, 2 C, and 3 C as compared with the batteries that lacked one or more of those components (Batteries 1[#]-4[#] and S1[#]-S4[#]). Ex. 1006, ¶¶146-147. In Figure 35, the mark ① above the data of the thickness expansion rate and the capacity retention rate after circulations represents the data related to regular-

shaped batteries 1-17 and 1[#]-4[#], and ② represents the data related to irregular-shaped batteries S1-S17 and S1[#]-S4[#]. Ex. 1006, ¶142.

		50% of the full charge capacity		DCIR		Discharge capacity retention rate of different rate capacity/%							
				(mohm)		0.5 C		1 C		2 C		3 C	
①	②	①	②	①	②	①	②	①	②	①	②	①	②
Exemplary Electrolytes	Battery1	S1		56.6	43.2	95.4	96.3	88.6	89.6	77.9	79.9	67.2	68.1
	Battery2	S2		52.4	41.5	94.9	95.8	87.5	88.1	76.5	78.6	66.9	67.9
	Battery3	S3		45.3	35.5	96.3	96.1	88.9	88.9	78.3	78.7	67.3	67.8
	Battery4	S4		50.5	38.6	94.3	94.8	87.6	88.6	76.9	77.9	66.9	68.9
	Battery5	S5		51.8	45.6	93.8	95.9	85.3	87.3	76.2	77.2	65.8	66.2
	Battery6	S6		50.9	43.4	95.2	95.7	86.2	87.3	75.9	78.1	67.1	67.3
	Battery7	S7		55.9	42.1	96.1	96.4	84.9	85.5	74.6	78.6	66.3	66.8
	Battery8	S8		54.3	33.8	94.5	97.2	84.3	93.1	73.5	90.5	65.6	87.6
	Battery9	S9		51.2	42.2	93.9	94.7	85.1	86.3	74.1	74.9	64.9	66.9
	Battery10	S10		59.8	46.2	94.2	94.9	84.9	85.3	75.2	76.4	65.1	67.5
	Battery11	S11		55.2	45.1	95.6	95.8	86.3	86.1	75.0	76.3	66.2	67.2
	Battery12	S12		58.4	46.1	92.8	93.8	85.3	85.8	75.3	77.3	65.8	66.8
	Battery13	S13		57.2	47.3	92.1	92.6	85.9	86.2	74.6	76.3	65.2	65.7
	Battery14	S14		56.7	45.3	93.2	93.1	88.6	87.7	75.5	77.8	67.9	68.4
	Battery15	S15		54.2	38.9	94.4	93.7	89.7	88.5	76.5	78.6	68.3	69.8
	Battery16	S16		51.5	30.6	96.4	97.8	88.5	94.5	77.3	91.3	66.6	88.3
	Battery17	S17		53.5	32.4	95.1	97.3	86.5	94.1	75.2	90.8	65.9	87.9
Comparative Electrolytes	Battery1 [#]	S1 [#]		110.2	145.2	83.5	81.7	73.2	71.2	67.5	64.5	57.6	55.6
	Battery2 [#]	S2 [#]		124.8	165.2	82.3	80.3	70.5	69.5	62.7	60.7	55.3	53.3
	Battery3 [#]	S3 [#]		109.4	134.7	85.6	80.6	72.4	70.4	65.4	64.4	56.2	54.2
	Battery4 [#]	S4 [#]		103.7	142.5	84.1	81.1	71.5	71.3	64.3	63.3	55.1	54.1

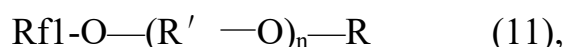
Figure 35: DC Internal Resistance and Discharge Capacity Retention Rates of Exemplary Batteries in Zhuang

2. **Claim 7: “The electrolyte according to claim 1, further comprising a fluoroether comprising at least one of the compounds of Formula (8), Formula (9), Formula (10) or Formula (11). . .”**

265. In my opinion, the combination of Hong and Zhuang renders obvious claim 7.

266. Claim 7 of the '363 patent recites:

The electrolyte according to claim 1, further comprising a fluoroether comprising at least one of the compounds of Formula (8), Formula (9), Formula (10) or Formula (11):



wherein Formulae (8), (9), (10), and (11), Rf1 and Rf2 are each independently a linear or branched C1 to C12 fluoroalkyl group having at least one hydrogen atom substituted with fluoro, R is a linear or branched C1 to C12 alkyl group, and R' is a linear or branched C1 to C5 alkylene group, and n is an integer from 1 to 5.

Ex. 1001, claim 7.

267. In my opinion, Zhuang discloses electrolytes of Formulas (8)-(11). Zhuang discloses Compounds B1-B7 as specific fluoroethers for use in the recited electrolyte. Ex. 1006, ¶¶105, 72. Zhuang demonstrates the efficacy of these fluoroethers in the examples. Ex. 1006, ¶¶143-148.

268. Compounds B1, B3, and B4 are compounds of Formula (8), as shown in Figure 36 below. For Compound B1, Rf1 is the linear C3 fluoroalkyl group $\text{HCF}_2\text{CF}_2\text{CH}_2\text{—}$ and Rf2 is the linear C2 fluoroalkyl group $\text{HCF}_2\text{CF}_2\text{—}$. For Compound B3, Rf1 is the branched C5 fluoroalkyl group $\text{CF}_3\text{CHFCH}_2(\text{CH}_3)\text{CH—}$ and Rf2 is the linear C3 fluoroalkyl group $\text{CF}_3\text{CFHCF}_2\text{—}$. For Compound B4, Rf1 is the linear C3 fluoroalkyl group $\text{CF}_3\text{CH}_2\text{CH}_2\text{—}$ and Rf2 is the linear C2 fluoroalkyl group $\text{HCF}_2\text{CH}_2\text{—}$.

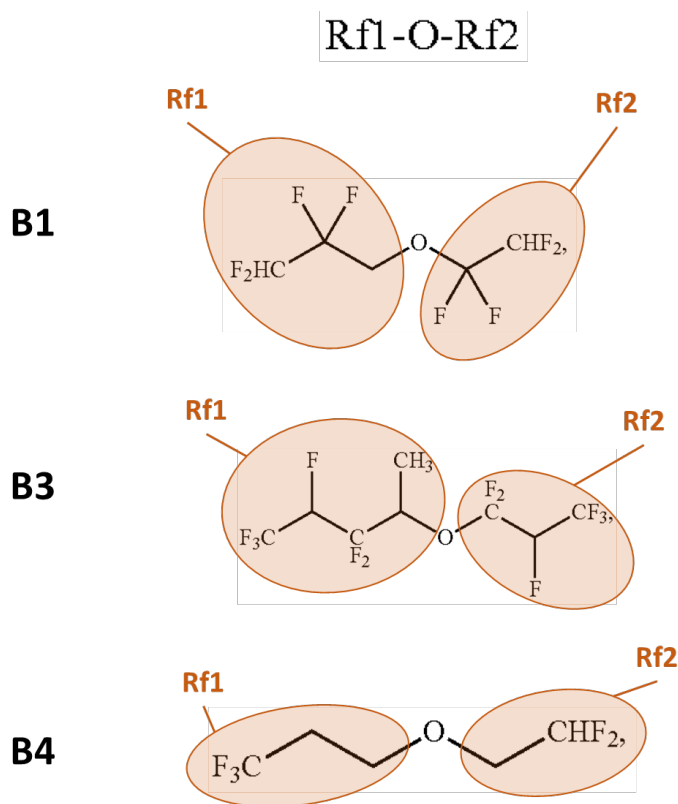


Figure 36: Compounds B1, B3, and B4 Satisfy Formula (8)

269. Compounds B2 and B5 are compounds of Formula (9), as shown in Figure 37 below. For Compound B2, Rf1 is the branched C6 fluoroalkyl

$(\text{CF}_3)_2\text{CF}(\text{CF}_3\text{CF}_2)\text{CF}-$, and R is the linear C1 alkyl group CH_3- . For Compound B5, Rf1 is the branched C4 fluoroalkyl group $\text{CH}_3\text{CF}_2(\text{CF}_3)\text{CH}-$, and R is the linear C1 alkyl group CH_3- .

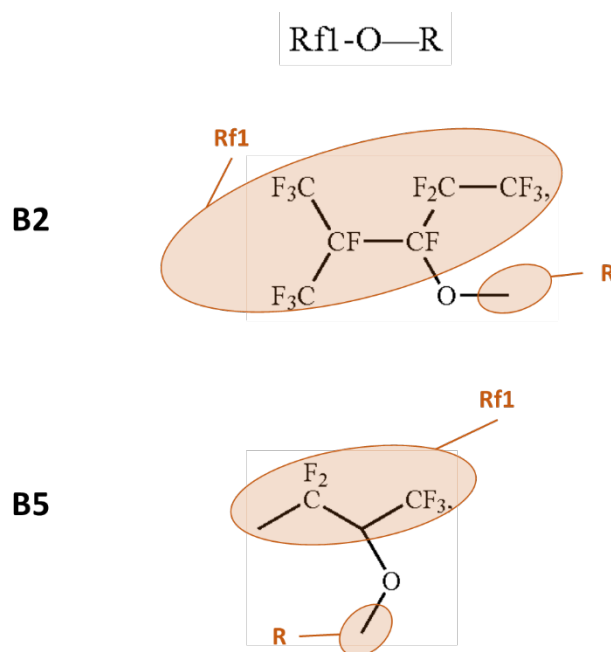


Figure 37: Compounds B2 and B5 Satisfy Formula (9)

270. Compound B6 is a compound of Formula (10), as shown in Figure 38 below. For Compound B6, Rf1 is the linear C2 fluoroalkyl group CF_3CF_2- , R' is the linear C1 fluoroalkyl group CF_2- , n equals 2, and Rf2 is the linear C2 fluoroalkyl group HCF_2CF_2- .

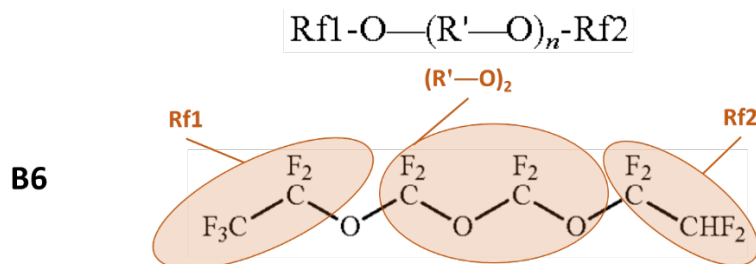


Figure 38: Compound B6 Satisfies Formula (10)

271. Compound B7 is a compound of Formula (11), as shown in Figure 39 below. For Compound B7, Rf1 is the linear C3 fluoroalkyl group $\text{CH}_3\text{CHFCH}_2\text{—}$, R' is the linear C2 fluoroalkyl group $\text{CHFCH}_2\text{—}$, n equals 1, and R is the linear C1 alkyl group $\text{CH}_3\text{—}$.

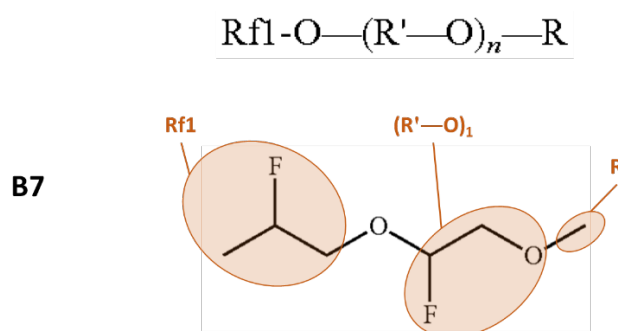


Figure 39: Compound B7 Satisfies Formula (11)

272. As I explained in Section XI.B.1 above, in my opinion, a person of ordinary skill in the art would have been motivated with a reasonable expectation of success to incorporate a fluoroether of Zhuang, such as one or more of Compounds B1-B7, into the electrolyte of Hong.

3. **Claim 8:** “The electrolyte according to claim 7, wherein Rf1 or Rf2 is each independently a fluoroalkyl group selected from the

group consisting of... $\text{HCF}_2\text{CF}_2\text{—...CF}_3\text{CF}_2\text{—...}$
 $\text{HCF}_2\text{CF}_2\text{CH}_2\text{—...}$.”

273. In my opinion, the combination of Hong and Zhuang renders obvious claim 8.

274. Zhuang discloses Compounds B1 and B6, which meet the limitation of Claim 8 of the '363 patent, as specific fluoroethers for use in the disclosed electrolyte. Ex. 1006, ¶¶105, 72. Zhuang demonstrates the efficacy of these fluoroethers in the examples. Ex. 1006, ¶¶143-148.

275. Compound B1 is a fluoroether of Formula (8), wherein Rf1 is the fluoroalkyl group $\text{HCF}_2\text{CF}_2\text{CH}_2\text{—}$, and Rf2 is the fluoroalkyl group $\text{HCF}_2\text{CF}_2\text{—}$, as shown in Figure 40 below.

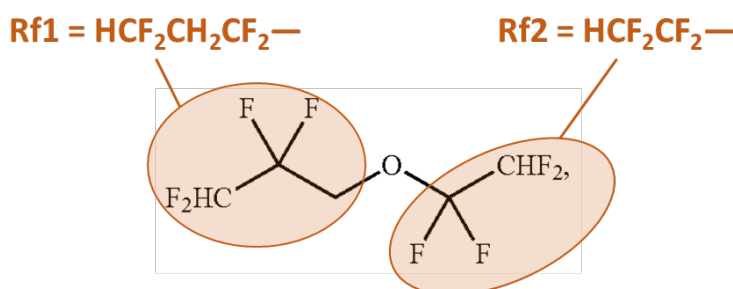


Figure 40: Compound B1 Contains Fluoroalkyl Groups Recited in Claim 8

276. Compound B6 is a fluoroether of Formula (10), wherein Rf1 is the fluoroalkyl group $\text{CF}_3\text{CF}_2\text{—}$, and Rf2 is the fluoroalkyl group $\text{HCF}_2\text{CF}_2\text{—}$, as shown in Figure 41 below.

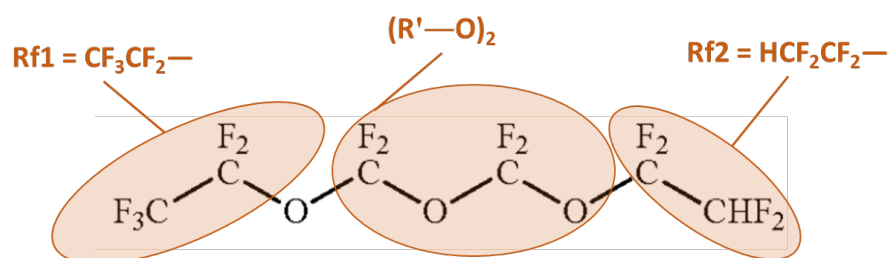


Figure 41: Compound B6 Contains Fluoroalkyl Groups Recited in Claim 8

277. As explained in Section XI.B.1 above, in my opinion, a person of ordinary skill in the art would have been motivated with a reasonable expectation of success to incorporate a fluoroether of Zhuang, such as Compound B1, into the electrolyte of Hong.

4. **Claim 9: “The electrolyte according to claim 7, wherein the fluoroether is one selected from the group consisting of $\text{HCF}_2\text{CF}_2\text{CH}_2\text{OCF}_2\text{CF}_2\text{H}$, $(\text{CF}_3)_2\text{CFCF}(\text{CF}_2\text{CF}_3)(\text{OCH}_3)$, $\text{CF}_3\text{CHF}_2\text{CF}_2\text{CH}(\text{CH}_3)\text{OCF}_2\text{CHF}_2\text{CF}_3$. . . and any combination thereof.”**

278. In my opinion, the combination of Hong and Zhuang renders obvious claim 9.

279. Zhuang discloses compounds B1, B2, and B3, which meet the limitation of Claim 9 of the '363 patent, as specific examples of fluoroether compounds for use in the recited electrolyte. Ex. 1006, ¶¶105, 72. Zhuang demonstrates the efficacy of these fluoroethers in the examples. Ex. 1006, ¶¶143-148.

280. Compound B1 is a fluoroether of formula $\text{HCF}_2\text{CF}_2\text{CH}_2\text{OCF}_2\text{CF}_2\text{H}$. Compound B2 is a fluoroether of formula $(\text{CF}_3)_2\text{CFCF}(\text{CF}_2\text{CF}_3)(\text{OCH}_3)$. Compound B3 is a fluoroether of formula $\text{CF}_3\text{CHF}_2\text{CF}_2\text{CH}(\text{CH}_3)\text{OCF}_2\text{CHF}_2\text{CF}_3$.

281. As explained in Section XI.B.1 above, in my opinion, a person of ordinary skill in the art would have been motivated with a reasonable expectation of success to incorporate a fluoroether of Zhuang, such as one or more of Compounds B1, B2, and B3, into the electrolyte of Hong.

C. Claim 10 of the '363 Patent Is Obvious over the Combination of Hong and Kim '685

282. In my opinion, for the reasons discussed below, the combination of Hong and Kim '685 renders obvious claim 10 of the '363 patent.

1. Motivation to Combine Hong and Kim '685

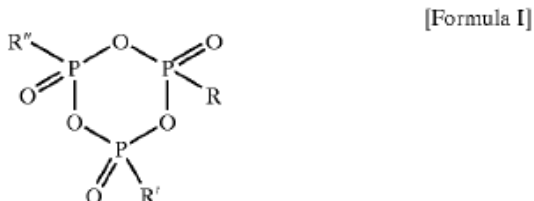
283. In my opinion, a person of ordinary skill in the art would have been motivated to modify the electrolyte of Hong to incorporate a cyclic phosphonic anhydride disclosed in Kim '685. It is my further opinion that a person of ordinary skill in the art would have had a reasonable expectation of success in modifying the electrolyte of Hong to incorporate a cyclic phosphonic anhydride disclosed in Kim '685.

284. Hong discloses electrolytes, including exemplary Embodiments 2, 18, and 25, that contain the carbonate-based organic solvents ethylene carbonate (EC),

diethyl carbonate (DEC), and propylene carbonate (PC). Ex. 1005, ¶¶34-35. Hong further discloses that lithium-ion batteries incorporating these electrolytes experienced battery expansion. Ex. 1005, ¶¶41, 31. For example, Embodiments 2, 18, and 25 experienced battery expansion during both the high-temperature cycle test (500 charge-discharge cycles at 45 °C) and the high-temperature storage performance test (stored fully charged for 30 days at 60 °C). Ex. 1005, ¶¶41, 31.

285. Kim '685 discloses that the decomposition of carbonate-based organic solvents such as ethylene carbonate and diethyl carbonate can cause gassing that leads to battery expansion. Ex. 1007, 2:10-3:10. Kim '685 further discloses that this gassing is a particular concern when the battery is stored at high temperature after charging. Ex. 1007, 3:14-20.

286. To inhibit gassing from the decomposition of carbonate-based organic solvents, Kim '685 discloses the incorporation of cyclic phosphonic anhydrides into the electrolyte. Ex. 1007, 3:14-20. In particular, Kim '685 discloses a type of cyclic phosphonic anhydride called a 1-alkylphosphonic acid cyclic anhydride, as shown in Figure 42 below.



where R, R', and R'' are alkyl groups having 1 to 4 carbon atoms.

Figure 42: Structure of 1-Alkylphosphonic Acid Cyclic Anhydride in Kim '685

287. Kim '685 states “[t]he 1-alkylphosphonic acid cyclic anhydride inhibits the decomposition of an organic solvent, thereby preventing an increase in the thickness of the battery when the battery is stored at a high temperature after charging.” Ex. 1007, 4:21-24.

288. In the examples, Kim '685 discloses electrolytes containing the organic solvent ethylene carbonate and between 0.5-5.0 wt % of 1-propanephosphonic acid cyclic anhydride (T3P). Ex. 1007, 4:65-5:17. These electrolytes were then injected into lithium-ion batteries for testing. Ex. 1007, 5:20-38.

Classification	EXAMPLE 1	EXAMPLE 2	EXAMPLE 3	EXAMPLE 4
Added amount (weight %)	0.5	1.0	2.0	5.0

Figure 43: Weight Percentage of T3P in Exemplary Electrolytes in Kim '685

289. To evaluate the electrolytes' effectiveness, Kim '685 tested the variation in battery thickness and capacity maintenance when stored at high temperature after charging. Ex. 1007, 5:39-6:40. The batteries were charged in an

electric current of 160 mA to a charge voltage of 4.2 V under the condition of CC-CV. Ex. 1007, 5:41-48. After allowing the batteries to sit for 1 hour, the batteries were discharged to 2.5 V with an electric current of 160 mA and left to sit for 1 hour. Ex. 1007, 5:41-48. This procedure was repeated three times, the batteries were charged in an electric current of 600 mA to a charge voltage of 4.2 V for 2 hours and 30 minutes. Ex. 1007, 5:48-50. The lithium secondary batteries were placed in a chamber of a high temperature of 85 °C for 4 days and the thicknesses of the batteries were measured every 24 hours. Ex. 1007, 5:50-53. In each instance and at each time point, the examples containing between 0.5-5.0 wt % of 1-propanephosphonic acid cyclic anhydride (Examples 1-4) experienced a lower degree of battery expansion and better retained their discharge capacity than a corresponding electrolyte that did not contain 1-propanephosphonic acid cyclic anhydride (Comparative Example 1), as shown in Figure 44 below. Ex. 1007, 5:55-65.

Classification	EXAM- PLE 1	EXAM- PLE 2	EXAM- PLE 3	EXAM- PLE 4	COMPARATIVE EXAMPLE 1
4 hours	5.9%	5.0%	5.0%	4.2%	8.8%
24 hours	9.1%	7.5%	5.9%	5.7%	11.6%
48 hours	12.4%	8.9%	7.2%	8.1%	13.4%
72 hours	17.2%	14.5%	11.4%	13.1%	17.4%
96 hours	21.5%	20.0%	15.6%	18.2%	22.0%

Figure 44: Exemplary Electrolytes in Kim '685 Containing T3P Experienced Less Battery Expansion Than One Without T3P

290. The examples containing between 0.5-5.0 wt % of 1-propanephosphonic acid cyclic anhydride also better maintained their discharge capacity, as shown in Figure 45 below. Ex. 1007, 6:15-23.

Classification	EXAM- PLE 1	EXAM- PLE 2	EXAM- PLE 3	EXAM- PLE 4	COMPARATIVE EXAMPLE 1
Maintenance ratio of dis- charge capacity	82.5%	84.4%	85.0%	85.3%	82.0%

Figure 45: Exemplary Electrolytes in Kim '685 Containing T3P Better Maintained Their Discharge Capacity Than One Without T3P

291. In my opinion, a person of ordinary skill in the art would have understood that a new additive can supplement the benefits of the additives already present in the electrolyte. In other words, although the expansion for the batteries tested in Kim '685 exceeded the expansion measured in Hong, a person of ordinary skill in the art would have understood that the cyclic phosphonic anhydride of Kim '685 could further reduce the expansion of the battery in Hong. In my opinion, a person of ordinary skill in the art would have been motivated by the disclosure in Kim '685 that cyclic phosphonic anhydrides mitigated the gassing problem from the decomposition of carbonate solvents—solvents that were also present in the electrolyte of Hong.

292. In my opinion, a person of ordinary skill in the art would have had a reasonable expectation of success in modifying the electrolyte of Hong to incorporate a cyclic phosphonic anhydride of Kim '685.

293. As an initial matter, Hong and Kim '685 overlap with respect to the non-additive components of the lithium-ion battery. For example, Kim '685 states that “[a]n organic solvent such as a cyclic or chained carbonate, or a mixture of two or more solvents can be used as a non-aqueous organic solvent in the present invention.” Ex. 1007, 4:25-27. Kim '685 specifically identifies ethylene carbonate and diethyl carbonate as organic solvents considered by the invention, and discloses results from testing electrolytes comprising ethylene carbonate in the examples. Ex. 1007, 4:25-30, 4:66-5:10. Embodiments 2, 18, and 25 of Hong contain the cyclic carbonate compounds ethylene carbonate and propylene carbonate and the chain carbonate compound diethyl carbonate as organic solvents. Ex. 1005, ¶¶34-35. Kim '685 and Hong further disclose example embodiments that rely upon the same lithium salt (LiPF_6). Ex. 1007, 4:66-5:10; Ex. 1005, ¶¶34-35.

294. Moreover, Hong discloses a method of preparing an electrolyte. Ex. 1005, ¶26. A person of ordinary skill in the art would have understood how to modify Hong's electrolyte preparation method to produce an electrolyte further comprising a cyclic phosphonic anhydride of Kim '685. Further, claim 10 does not have an efficacy requirement, and it is rare that an additive would eliminate the functionality

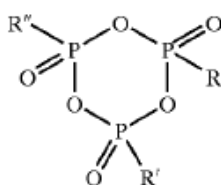
of a given electrolyte. Thus, in my opinion, a person of ordinary skill in the art would have had a reasonable expectation of success in producing a functional electrolyte in modifying the electrolyte disclosed in Hong to incorporate a cyclic phosphonic anhydride of Kim '685.

2. [10pre]: “The electrolyte according to claim 1, further comprising”

295. As explained in Section XI.A.1 above, Hong discloses an electrolyte according to claim 1. In my opinion, the electrolyte of Hong modified to incorporate a cyclic phosphonic anhydride of Kim '685 similarly discloses an electrolyte according to claim 1.

3. [10.a]: “a cyclic phosphonic anhydride”

296. In my opinion, the electrolyte of Hong as modified by Kim '685 discloses a cyclic phosphonic anhydride. In particular, Kim '685 discloses a type of cyclic phosphonic anhydride called a 1-alkylphosphonic acid cyclic anhydride that has the structure shown in Figure 46 below.

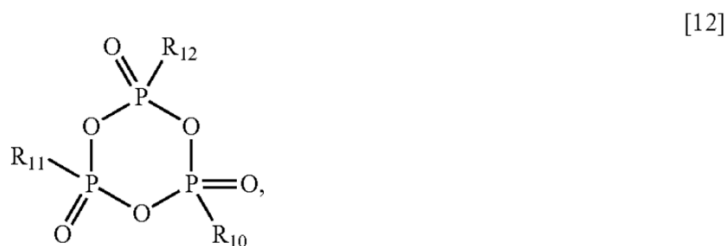


[Formula I]

where R, R', and R'' are alkyl groups having 1 to 4 carbon atoms.

Figure 46: Structure of 1-Alkylphosphonic Acid Cyclic Anhydride in Kim '685

297. I note that the '363 patent describes cyclic phosphonic anhydrides having a structure that encompasses the 1-alkylphosphonic acid cyclic anhydrides of Kim '685. As shown in Figure 47 below, the '363 patent describes cyclic phosphonic anhydrides that have the same basic structure as Kim '685.



wherein in Formula [12], R_{10} , R_{11} , and R_{12} each independently may be hydrogen; each independently may be an alkyl group having 1-20 carbon atoms, for example, an alkyl

Figure 47: Structure of Exemplary Phosphonic Cyclic Anhydride in the '363 Patent

298. As explained in Section XI.C.1 above, a person of ordinary skill in the art would have been motivated with a reasonable expectation of success to modify the electrolyte of Hong to incorporate the cyclic phosphonic anhydride of Kim '685.

4. [10.b]: “based on the total weight of the electrolyte, a content of cyclic phosphonic anhydride is about 0.01-10 wt%.”

299. In my opinion, the electrolyte of Hong as modified by Kim '685 would contain cyclic phosphonic anhydride in an amount between about 0.01-10 wt % of the total electrolyte.

300. Kim '685 states that “1-alkylphosphonic acid cyclic anhydride is added to a non-aqueous organic solvent in an amount of 0.1 to 10 weight %.” Ex. 1007,

4:11-14. Kim '685 provides a rationale for keeping the amount of 1-alkylphosphonic acid cyclic anhydride within this range. Specifically, when the weight percentage of 1-alkylphosphonic acid cyclic anhydride is below 0.1 wt %, gassing inhibition is “not likely,” but above 10 wt %, the 1-alkylphosphonic acid cyclic anhydride leads to decreased initial charge and discharge efficiencies and reduced cycle life performance of the battery. Ex. 1007, 4:14-20.

301. In my opinion, the electrolyte of Hong as modified in view of Kim '685 would still satisfy the ranges recited in Formulas (1)-(3) of claim 1 when accounting for the added 1-alkylphosphonic acid cyclic anhydride. When incorporating a new additive, a person of ordinary skill in the art would have either reduced the proportion of the base solvent or reduced the proportion of all electrolyte components by the same percentage. Under either choice, the electrolytes recited in Embodiments 2, 18, and 25 of Hong would still satisfy Formulas (1) and (2). If the proportion of dinitrile and trinitrile compounds remained the same, as under the first choice, Embodiments 2, 18, and 25 of Hong would satisfy Formulas (1) and (2) for the reasons discussed in Section XI.A.1.e and XI.A.1.f above. If the proportion of dinitrile and trinitrile compounds was reduced, as under the second choice, they would reduce by at most one-tenth. Because the minimum value for $X + Y$ in Embodiments 2, 18, and 25 is 4.8, a one-tenth reduction in that value would still satisfy Formula (1). For Formula (2), because the dinitrile (X) and trinitrile (Y)

weight percentages would both be reduced by an equal ratio, the values for X/Y would be unchanged (e.g., $0.9X/0.9Y = X/Y$).

302. Under either choice, the electrolytes recited in Embodiments 2, 18, and 25 of Hong would also still satisfy Formula (3) when accounting for the added 1-alkylphosphonic acid cyclic anhydride. For similar reasons as discussed for Formula (2), if the weight proportion of all electrolyte components was reduced equally when adding the 1-alkylphosphonic acid cyclic anhydride, the trinitrile (Y) and propyl propionate (Z) components would both be reduced by an equal ratio, so the values for Y/Z would be unchanged (e.g., $0.9Y/0.9Z = Y/Z$).

303. If just the proportion of the base solvent was reduced, Embodiments 2 and 25 would satisfy Formula (3) even if the electrolyte contained 10 wt % of the 1-alkylphosphonic acid cyclic anhydride. To evaluate Formula (3), I have calculated the change to the proportion of propyl propionate for Embodiments 2 and 25 in Table 20 and Table 21 below using the same process and assumptions described in Section XI.A.1.g, modified to include 1-propanephosphonic acid anhydride as a liquid additive. Ex. 1023.

	Compound	Density	Volume	Contribution	Wt%
Base Solvent		g/ml	Vol, ml	Weight, g	Total Electrolyte
	EC	1.321	18.93	25.00	
	PP	0.881	28.38	25.00	
	DEC	0.975	41.03	40.00	

	PC	1.204	8.31	10.00	
	Sum Base Solvent	N/A	96.65	100.00	
Liquid Additives	ADN	0.961	3.27	3.14	2.00
	VEC	1.188	0.40	0.47	0.30
	DENE	1.07	1.47	1.57	1.00
	FEC	1.485	5.29	7.85	5.00
	T3P	1.039	15.11	15.70	10.00
	Compound I ₁	0.60	2.10	1.26	0.80
	Sum Liquid Additives	N/A	27.64	29.99	
	Sum Liquid Components	N/A	124.29	129.99	
Solid Additives	SN	0.985	0.00	1.57	1.00
	PS	1.392	0.00	4.71	3.00
Lithium Salt	LiPF ₆ (1.1 M; MW = 151.91 g/mol)	2.83	0.00	20.77	
	Sum Solid Components	N/A	0.00	27.05	
	Sum All Components	N/A	124.29	157.04	
	PP weight %			15.9%	

Table 20: Weight Percentage of Components in Embodiment 2 of Hong Modified to Contain 10 wt % of 1-Propanephosphonic Cyclic Acid Anhydride if Base Solvent Proportion is Reduced

	Compound	Density	Volume	Contribution	Wt%
Base Solvent		g/ml	Vol, ml	Weight, g	Total Electrolyte
	EC	1.321	18.93	25.00	
	PP	0.881	28.38	25.00	
	DEC	0.975	41.03	40.00	
	PC	1.204	8.31	10.00	
	Sum Base Solvent	N/A	96.65	100.00	
Liquid Additives	ADN	0.961	3.83	3.68	2.00
	DENE	1.07	1.72	1.84	1.00
	FEC	1.485	6.20	9.20	5.00
	HTCN	1.04	0.88	0.92	0.50
	T3P	1.039	17.71	18.40	10.00
	Compound II ₆	0.60	4.60	2.76	1.50
	Sum Liquid Additives	N/A	34.94	36.80	
	Sum Liquid Components	N/A	131.59	136.80	
Solid Additives	SN	0.985	0.00	1.84	1.00
	DTD	1.73	0.00	0.92	0.50
	PS	1.392	0.00	5.52	3.00

Lithium Salts	LiTFSI (0.5 M; MW = 287.09 g/mol)	2.15	0.00	18.89	
	LiPF ₆ (1.0 M; MW = 151.91 g/mol)	2.83	0.00	19.99	
	Sum Solid Components	N/A	0.00	47.16	
	Sum All Components	N/A	131.59	183.96	
	PP weight %			13.6%	

Table 21: *Weight Percentage of Components in Embodiment 25 of Hong Modified to Contain 10 wt % of 1-Propanephosphonic Cyclic Acid Anhydride if Base Solvent Proportion is Reduced*

304. For Embodiment 2, the weight percentage of propyl propionate would be 15.9 wt % (i.e., Z = 15.9 wt %). Thus, $Y/Z = 0.8/15.9 = 0.05$. For Embodiment 25, the weight percentage of propyl propionate would be 13.6 wt % (i.e., Z = 13.6 wt %). Thus, $Y/Z = 2/13.6 = 0.15$. Accordingly, Embodiments 2 and 25 would satisfy Formula (3) if the electrolyte contained 10 wt % of the 1-alkylphosphonic cyclic anhydride.

305. Embodiment 18 would satisfy Formula (3) as long as the electrolyte contained about 3 wt % or less of the 1-alkylphosphonic acid cyclic anhydride. These amounts fall within the range considered by Kim '685. Ex. 1007, 4:11-14 ("1-alkylphosphonic acid cyclic anhydride is added to a non-aqueous organic solvent in an amount of 0.1 to 10 weight %"). In the examples, Kim '685 discloses that exemplary electrolytes containing 0.5, 1.0, and 2.0 wt % of 1-propanephosphonic acid cyclic anhydride each resulted in a lower rate of battery thickness expansion at all tested time points and a higher maintenance ratio of discharge capacity relative

to a comparative electrolyte that contained 1-propanephosphonic acid cyclic anhydride. Ex. 1007, 5:5-6:23.

306. To evaluate Formula (3), I have calculated the change to the proportion of propyl propionate for Embodiment 18 in Table 22 below.

	Compound	Density	Volume	Contribution	Wt%
Base Solvent		g/ml	Vol, ml	Weight, g	Total Electrolyte
	EC	1.321	18.93	25.00	
	PP	0.881	28.38	25.00	
	DEC	0.975	41.03	40.00	
	PC	1.204	8.31	10.00	
	Sum Base Solvent	N/A	96.65	100.00	
Liquid Additives	ADN	0.961	3.15	3.03	2.00
	VEC	1.188	0.38	0.45	0.30
	DENE	1.07	1.41	1.51	1.00
	FEC	1.485	5.10	7.57	5.00
	T3P	1.039	4.37	4.54	3.00
	Compound I ₁	0.60	12.62	7.57	5.00
	Sum Liquid Additives	N/A	27.03	24.67	
	Sum Liquid Components	N/A	123.68	124.67	
Solid Additives	SN	0.985	0.00	1.51	1.00
	PS	1.392	0.00	4.54	3.00
Lithium Salt	LiPF ₆ (1.1 M; MW = 151.91 g/mol)	2.83	0.00	20.67	
	Sum Solid Components	N/A	0.00	26.72	
	Sum All Components	N/A	123.68	151.39	
	PP weight %			16.5%	

Table 22: Weight Percentage of Components in Embodiment 18 of Hong Modified to Contain 5 wt % of 1-Propanephosphonic Cyclic Acid Anhydride if Base Solvent Proportion is Reduced

307. For Embodiment 18, the weight percentage of propyl propionate would be 16.5 wt % (i.e., Z = 16.5 wt %). Thus, Y/Z = 5/16.5 = 0.30. Accordingly,

Embodiment 18 would satisfy Formula (3) if the electrolyte contained as much as 5 wt % of the 1-alkylphosphonic cyclic anhydride.

D. Claim 12 of the '363 Patent is Obvious over the Combination of Hong and Kim '934

308. In my opinion, for the reasons discussed below, the combination of Hong and Kim '934 renders obvious claim 12 of the '363 patent.

1. Motivation to Combine Hong and Kim '934

309. In my opinion, a person of ordinary skill in the art would have been motivated to modify the electrolyte of Hong to incorporate a cyclic carboxylate ester disclosed in Kim '934. It is my further opinion that a person of ordinary skill in the art would have had a reasonable expectation of success in modifying the electrolyte of Hong to incorporate a cyclic carboxylate ester disclosed in Kim '934.

310. Hong discloses electrolytes, including exemplary Embodiment 25, that contain 1,3,6-hexane tricarbonitrile (HTCN). Ex. 1005, ¶35. Hong discloses that these electrolytes provide improved high-temperature and high-voltage performance. Ex. 1005, ¶¶2, 5.

311. Kim '934 similarly discloses electrolytes that offer improved performance at high temperature and high voltage. Ex. 1008, ¶8. In particular, Kim '934 discloses electrolytes comprising a trinitrile compound of Chemical Formula 1 and a cyclic carboxylate ester of Chemical Formula 2, shown in Figure 48 below.

Ex. 1008, ¶¶10-13. Kim '934 discloses that the compound of Chemical Formula 1 may be 1,3,6-hexanetricarbonitrile (HTCN) and the compound of Chemical Formula 2 may be γ -butyrolactone (GBL) or γ -valeroactone. Ex. 1008, ¶¶15, 38.

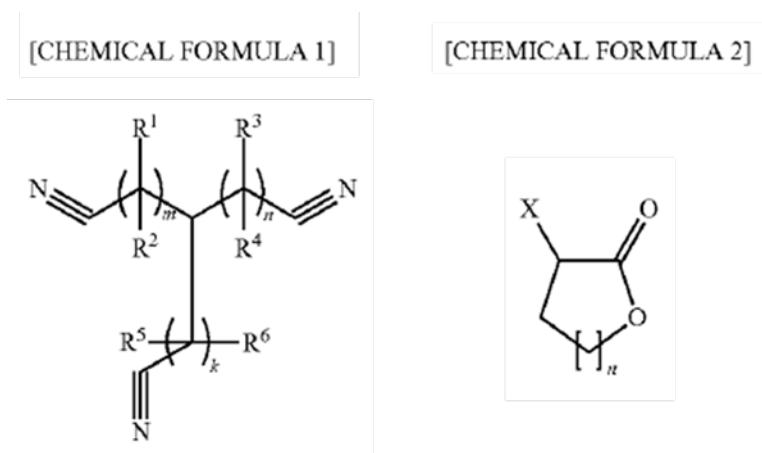


Figure 48: Structures of Chemical Formula 1 and Chemical Formula 2 in Kim '934

312. Kim '934 explains that the combination of a trinitrile compound of Chemical Formula 1 and a cyclic carboxylate ester of Chemical Formula 2 can offer synergistic benefits to the electrolyte. Ex. 1008, ¶41. The benefits include lower gassing at high temperature or following thermal impact, better capacity retention at high temperature, and lower thickness increase at high temperature. Ex. 1008, ¶¶41, 112-140; *infra.*, XI.D.1.a-XI.D.1.b. These are standard measures of battery performance that a person of ordinary skill in the art would have been motivated to improve. Indeed, Hong explicitly aims to reduce battery thickness expansion at high temperatures and improve battery capacity retention at high temperatures. *See* Ex. 1005, ¶43 (“[A] tricyanophosphite compound or a tricyanophosphate compound can

effectively improve the battery's cycling performance, *significantly increase the battery's capacity retention rate after storage at a high temperature, suppress thickness expansion*, and mitigate lithium precipitation during low-temperature charging.”) (emphasis added); *see also* ¶¶30-31, 39-42.

313. In the examples, Kim '934 discloses exemplary electrolytes containing hexane tricyanide (HTCN) and γ -butyrolactone (GBL) present in various weight percentages that achieve these synergistic benefits from the combination of that cyclic carboxylate ester with 1,3,6-hexane tricarbonitrile (HTCN). Ex. 1008, ¶¶90, 96, 98. In my opinion, a person of ordinary skill in the art would have been motivated by Kim '934 to modify the electrolyte of Hong to incorporate a cyclic carboxylate ester, such as γ -butyrolactone (GBL) or γ -valeroactone, in order to achieve the described synergistic benefits.

314. In my opinion, a person of ordinary skill in the art would have had a reasonable expectation of success in modifying the electrolyte of Hong to incorporate a cyclic carboxylate ester of Kim '934. As an initial matter, Hong states that the electrolyte may contain γ -butyrolactone (GBL). Ex. 1005, ¶13. Moreover, Hong and Kim '934 overlap substantially with respect to the components of their respective lithium-ion batteries. For example, Kim '934 states “the non-aqueous organic solvent may include a carbonate-based, ester-based, ether-based, ketone-based, alcohol-based, or aprotic solvent.” Ex. 1008, ¶46. Kim '934 further states “the

carbonate-based solvent. . . diethyl carbonate (DEC). . . ethylene carbonate (EC), propylene carbonate (PC). . . and the like.” Ex. 1008, ¶47. Embodiment 25 of Hong contains the carbonate-based solvents DEC, EC, and PC and the ester-based solvent propyl propionate. Ex. 1005, ¶35. Additionally, the example electrolytes in Kim ’934 and Embodiment 25 of Hong both contain lithium hexafluorophosphate (LiPF₆) as a lithium salt. Ex. 1008, ¶90; Ex. 1005, ¶35.

315. Kim ’934 further states that “the electrolyte may include at least one additive selected from fluoroethylene carbonate, vinylene carbonate, succinonitrile, polysulfone and a combination thereof.” Ex. 1008, ¶42. Kim ’934 explains that “[w]hen these additives are further included, the additives may help formation of a film on a negative electrode as well as the positive electrode and thus efficiently suppress gas generation from the positive and negative electrodes during the storage at a high temperature.” Ex. 1008, ¶42. Embodiment 25 of Hong contains fluoroethylene carbonate and succinonitrile. Ex. 1005, ¶35.

316. Further, Hong discloses a method of preparing an electrolyte. Ex. 1005, ¶26. A person of ordinary skill in the art would have understood how to modify Hong’s electrolyte preparation method to produce an electrolyte further comprising a cyclic carboxylate ester of Kim ’934. Further, claim 12 does not have an efficacy requirement, and it is rare that an additive would eliminate the functionality of a given electrolyte. Thus, in my opinion, a person of ordinary skill in the art would

have had a reasonable expectation of success in producing a functional electrolyte in modifying the electrolyte disclosed in Hong to incorporate a cyclic carboxylate ester of Kim '934.

a. Kim '934 Demonstrates that GBL and HTC� Increase Capacity Retention, Reduce Battery Thickness Change Rate, and Reduce the Amount of Carbon Dioxide Generated at High Temperature

317. Kim '934 discloses exemplary electrolytes containing hexane tricyanide (HTCN) and γ -butyrolactone (GBL). Ex. 1008, ¶¶90, 96, 98. Kim '934 also discloses comparative electrolytes containing no hexane tricyanide or γ -butyrolactone, just hexane tricyanide, just γ -butyrolactone, or γ -butyrolactone and hexane tricyanide present in weight percentages outside the preferred range. Ex. 1008, ¶¶100-111.

318. To evaluate the capacity retention when the battery was allowed to stand at high temperature, the batteries were once charged at 0.5 C and discharged at 0.2 C to determine the initial discharge capacity. Ex. 1008, ¶121. The batteries were then fully charged under a condition of 0.5 C and 4.4 V and allowed to stand at 60° C for 4 weeks, once discharged at 0.2 C, before measuring the discharge capacity. Ex. 1008, ¶122. Kim '934 discloses that the batteries “using the electrolyte including both HTC� and GBL according to Examples 1 to 3 showed high capacity retention at a high temperature compared with the rechargeable lithium battery cells

using an electrolyte including no HTCN and GBL or just one of the HTCN and the GBL.” Ex. 1008, ¶127. Kim ’934 further discloses that the batteries “including both of the HTCN and the GBL but using them out of the range of 0.05 wt % to 10 wt % . . . showed deteriorated capacity retention compared with the” batteries containing HTCN and GBL within that range, as shown in Figure 49, Figure 50, and Figure 51 below. Ex. 1008, ¶128, Table 1, Figs. 5, 6.

	HTCN (wt %)	GBL (wt %)	Initial capacity (mAh)	Capacity after being allowed to stand at 60° C. for 4 weeks (mAh)	Capacity retention (%)	Initial thickness (µm)	Thickness after being allowed to stand at 60° C. for 4 weeks (µm)	Thickness change rate (%)
Example 1	2	1.5	2920	2270	77.7	5.28	6.10	16
Example 2	2	3	2919	2265	77.6	5.23	5.82	11
Example 3	2	5	2933	2310	78.8	5.22	5.66	8
Comparative Example 1	0	0	2940	1970	67.0	5.35	7.36	38
Comparative Example 2	2	0	2931	2150	73.4	5.30	6.49	22
Comparative Example 3	0	3	2932	2210	75.4	5.29	6.06	15
Comparative Example 4	0.04	10	2915	1980	67.9	5.25	6.80	30
Comparative Example 5	2	0.04	2920	2180	75.7	5.29	6.47	22
Comparative Example 6	10.2	2	2800	2000	71.4	5.30	6.38	20

Figure 49: Comparison of Batteries with Electrolytes Containing Both GBL and HTCN in the Ranges Recited in Kim ’934 to Batteries Lacking One or Both of GBL and HTCN or Containing GBL or HTCN in Amounts Outside the Recited Ranges

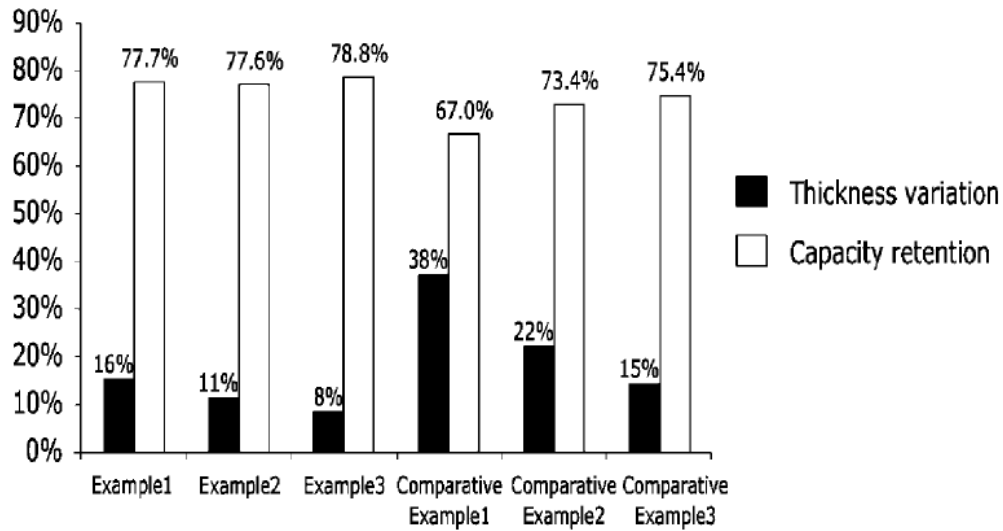


Figure 50: Batteries with Electrolytes Containing Both GBL and HTCN in the Ranges Recited in Kim '934 Demonstrated Lower Variation in Battery Thickness and Greater Capacity Retention at High Temperature

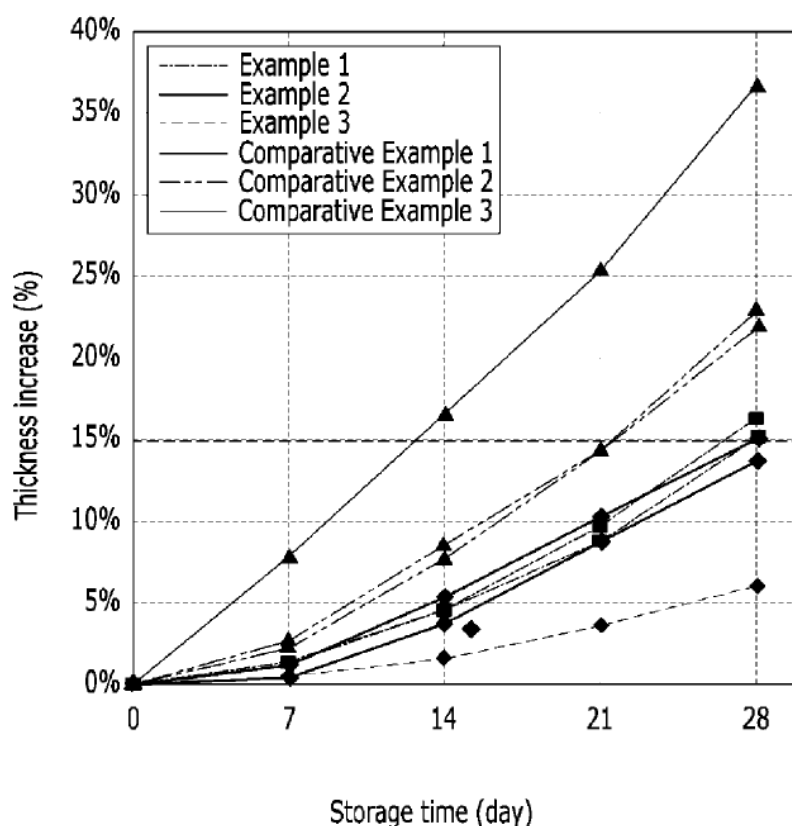


Figure 51: Batteries with Electrolytes Containing Both GBL and HTC in the Ranges Recited in Kim '934 Demonstrated Lower Variation in Battery Thickness at High Temperature

319. To evaluate the battery thickness change rate after being allowed to stand at high temperature, the batteries were once initially charged and discharged at 0.5 C/0.2 C, fully charged under a condition of 0.2 C and 4.4 V before measuring the initial thickness. Ex. 1008, ¶125. The batteries were then allowed to stand at 60 °C for 4 weeks and the thickness was measured again. Ex. 1008, ¶125. Kim '934 discloses that the batteries “using the electrolyte including the HTC and the GBL according to Examples 1 to 3 were effectively suppressed from a thickness increase after allowed to stand at 60 °C for 4 weeks compared with the rechargeable lithium

battery cells using the electrolyte including no HTCEN and GBL or just one of the HTCEN and the GBL.” Ex. 1008, ¶127. Kim ’934 further discloses that the batteries “the cells including both of the HTCEN and the GBL but using them out of the range of 0.05 wt % to 10 wt %. . . [showed] a high thickness increase rate after being allowed to stand at 60 °C for 4 weeks compared with the” batteries containing HTCEN and GBL within that range, as shown in Figure 49, Figure 50, and Figure 51 above. Ex. 1008, ¶128, Table 1, Figs. 5, 6.

320. To evaluate the gas generated after the batteries were allowed to stand at high temperature, the batteries were allowed to stand at 60 °C for 4 weeks, after which the generated gas was analyzed by gas chromatography. Ex. 1008, ¶130. Kim ’934 discloses that the electrolytes containing HTCEN and GBL “generated remarkably less CO₂ gas mainly due to their oxidation decomposition reaction,” as shown in Figure 52 below and Figure 49 above. Ex. 1008, ¶131, Table 1, Fig. 7.

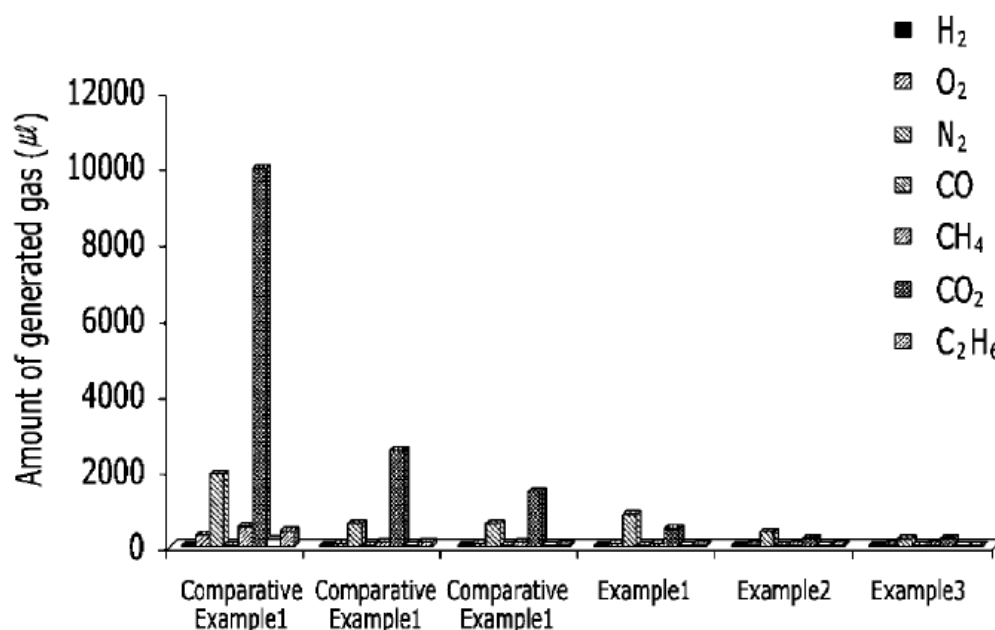


Figure 52: Batteries with Electrolytes Containing Both GBL and HTC� in the Ranges Recited in Kim '934 Demonstrated Lower CO₂ Generation at High Temperature

b. Kim '934 Demonstrates that GBL and HTC� Reduce the Effect of a Thermal Impact on Capacity Retention

321. To evaluate the effect of a thermal impact on capacity retention and battery thickness change rate, the batteries were once charged at 0.5 C/discharged at 0.2 C before measuring the initial discharge capacity. Ex. 1008, ¶133. The batteries were then fully charged under a condition of 0.5 C and 4.4 V, then their thermal impact experiments were performed by 20 times repetitively heating up to 85 °C and maintaining them there for 2 hours, then cooling them down, and then maintaining them at -40 °C for 2 hours to give a thermal stress. Ex. 1008, ¶134. The batteries

were then once charged at 0.5 C/discharged at 0.2 C and the capacity was measured.
Ex. 1008, ¶134.

322. Kim '934 discloses that the batteries “using the electrolyte including HTCN and GBL. . . showed high capacity retention and a small thickness change rate after a thermal impact experiment. . . compared with the rechargeable lithium battery cell using the electrolyte including no HTCN and GBL. . . or the rechargeable lithium battery cell using the electrolyte including just only the HTCN,” as shown in Figure 53 and Figure 54 below. Ex. 1008, ¶139, Table 2, Fig. 8.

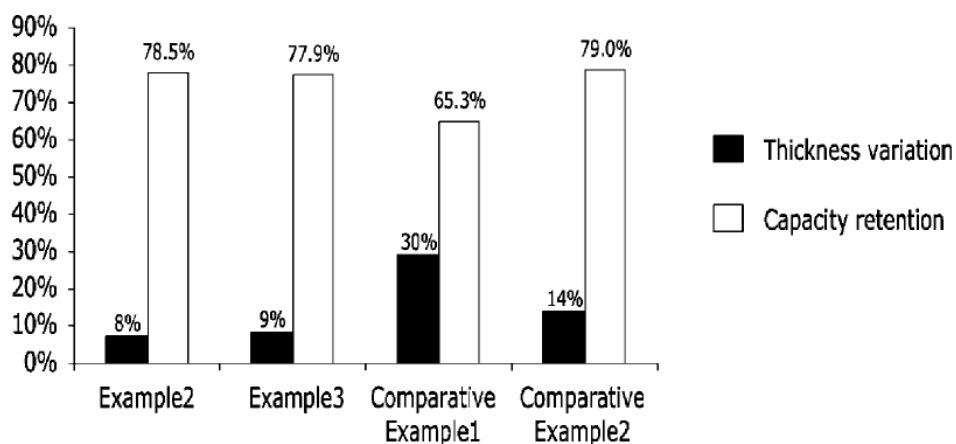


Figure 53: Batteries with Electrolytes Containing Both GBL and HTCN in the Ranges Recited in Kim '934 Demonstrated Lower Variation in Battery Thickness and Better Capacity Retention after Thermal Impact Compared to Batteries with Electrolytes Containing No HTCN or GBL or Only HTCN

	HTCN (wt %)	GBL (wt %)	Initial capacity (mAh)	Capacity after thermal impact (mAh)	Capacity retention (%)	Initial thickness (μm)	Thickness after thermal impact (μm)	Thickness change rate (%)
Example 2	2	3	2904	2280	78.5	5.25	5.65	8
Example 3	2	5	2900	2260	77.9	5.22	5.67	9
Comparative Example 1	0	0	2920	1906	65.3	5.17	6.70	30
Comparative Example 2	2	0	2910	2300	79	5.21	5.96	14

Figure 54: Batteries with Electrolytes Containing Both GBL and HTCN in the Ranges Recited in Kim '934 Demonstrated Lower Variation in Battery Thickness and Better Capacity Retention after Thermal Impact Compared to Batteries with Electrolytes Containing No HTCN or GBL or Only HTCN

2. Claim 12: “The electrolyte according to claim 1, further comprising a cyclic carboxylate ester, including γ -butyrolactone or γ -valerolactone or a combination thereof.”

323. In my opinion, the combination of Hong and Kim '934 renders obvious claim 12.

324. In my opinion, the electrolyte of Hong as modified by Kim '934 discloses a cyclic carboxylate ester. Kim '934 discloses a cyclic carboxylate ester having a structure according to Chemical Formula 2. Ex. 1008, ¶¶30, 36. Kim '934 further discloses that the compound of Chemical Formula 2 may be γ -butyrolactone (GBL) or γ -valerolactone or a combination thereof. Ex. 1008, ¶38. In the examples, Kim '934 demonstrates the efficacy of electrolytes containing both γ -butyrolactone (GBL) and the trinitrile compound 1,3,6-hexanetricarbonitrile (HTCN). Ex. 1008, ¶90.

325. As explained above, it is my opinion that a person of ordinary skill in the art would have been motivated with a reasonable expectation of success to modify the electrolyte of Hong to incorporate a cyclic carbonate ester as taught by Kim '934. In particular, a person of ordinary skill in the art would have been motivated with a reasonable expectation of success to modify the electrolyte of Hong to incorporate γ -butyrolactone (GBL).

E. Claims 14-15 of the '363 Patent Are Obvious over the Combination of Fujikawa and Hong

326. In my opinion, for the reasons discussed below, the combination of Fujikawa and Hong renders obvious claims 14-15 of the '363 patent.

1. Motivation to Combine Fujikawa and Hong

327. In my opinion, a person of ordinary skill in the art would have been motivated to modify the lithium secondary battery of Fujikawa to incorporate the electrolyte of Hong. It is my further opinion that a person of ordinary skill in the art would have had a reasonable expectation of success in modifying the lithium secondary battery of Fujikawa to incorporate the electrolyte of Hong.

328. Fujikawa discloses improvements to battery structure. Fujikawa aims “to achieve both excellent safety and high output power in a lithium secondary battery in which a current collecting lead is connected to a substantially center

portion of an electrode.” Ex. 1009, ¶6. Fujikawa thus discloses batteries comprising a heat-resistant layer between the cathode and the anode. Ex. 1009, ¶6.

329. Fujikawa further discloses batteries wherein both the cathode and the anode comprise a coating comprising a single-sided coating and a double-sided coating. Ex. 1009, ¶¶66, 96-97, 89-91. In particular, Fujikawa discloses a battery wherein both the cathode and the anode comprise a single-sided coating (opposite a “center exposed portion,” 12a and 22a, respectively) and a double-sided coating and a heat-resistant layer 30 is formed on the anode, as shown in Figure 55 below. Ex. 1009, ¶96 (Example 38).

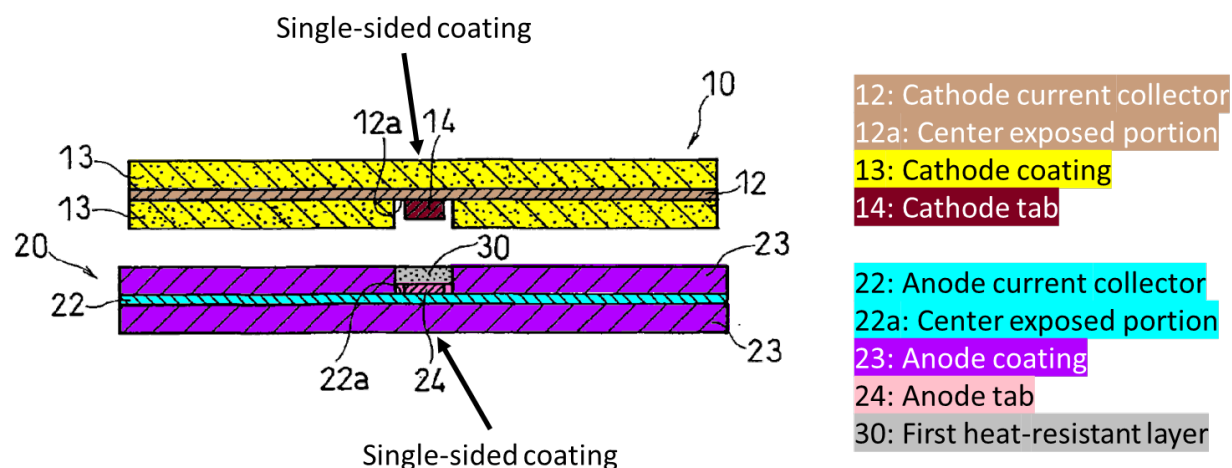


Figure 55: Battery of Fujikawa with One Heat-Resistant Layer on the Anode

330. Fujikawa further discloses a battery wherein both the cathode and the anode comprise a single-sided coating and a double-sided coating and a second heat-resistant layer 40 is formed on the anode, as shown in Figure 56 below. Ex. 1009, ¶97 (Example 39).

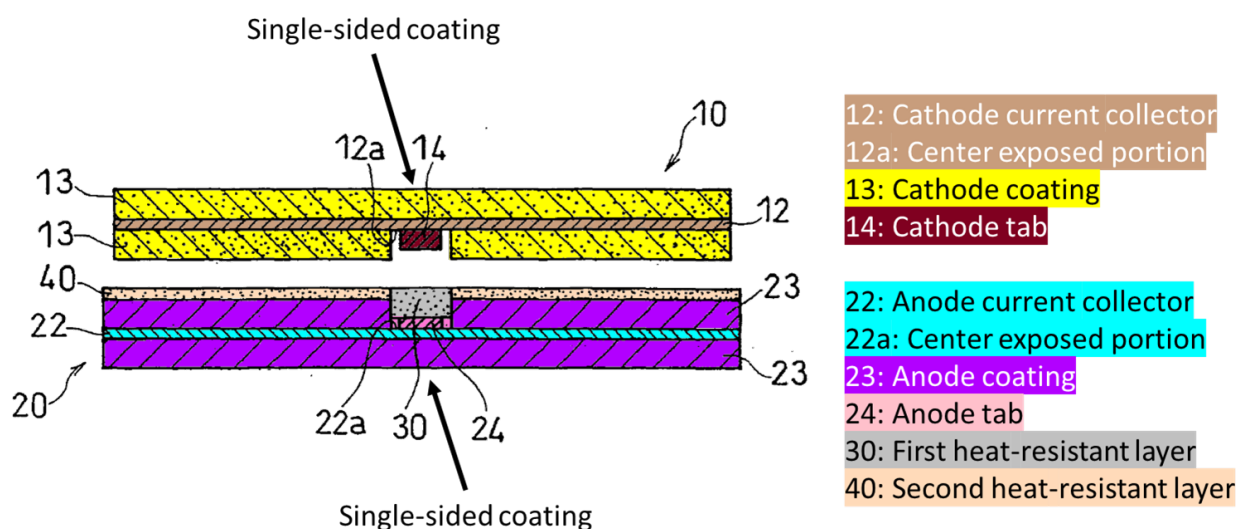


Figure 56: Battery of Fujikawa with Two Heat-Resistant Layers on the Anode

331. Fujikawa evaluated the output characteristics of the batteries by subjecting them to charge/discharge cycles and then measuring the discharge capacity at 0.2 C and at 3 C. Ex. 1009, ¶¶103-109. Fujikawa discloses that the coating comprising a single-sided coating and a double-sided coating offers benefits, stating “when the positive and negative electrodes each have a center exposed portion [as in Figures 55-56], further excellent high output characteristics can be obtained.” Ex. 1009, ¶116. I note that Fujikawa’s exemplary batteries comprising an anode and a cathode both having a single-sided and a double-sided coating demonstrated excellent rate capacity, having the highest ratio of discharge capacity at 0.2 C versus 3 C of all batteries tested. Ex. 1009, Table 3 (Examples 38 and 39). Fujikawa demonstrates the efficacy of this battery structure through testing with a conventional electrolyte. Ex. 1009, ¶69.

332. Hong discloses electrolytes that improve the high-temperature storage performance, cycling performance, and low-temperature charging performance of a lithium-ion battery. Ex. 1005, ¶5. In particular, Hong discloses that “[b]y comparing Embodiments 1-25 and Comparison Cases 1-6, it is found that the addition of a tricyanophosphite compound or a tricyanophosphate compound can effectively improve the battery’s cycling performance, significantly increase the battery’s capacity retention rate after storage at a high temperature, suppress thickness expansion, and mitigate lithium precipitation during low-temperature charging.” Ex. 1005, ¶43.

333. Embodiments 2-15, 18, 20-21, and 25 each disclose an electrolyte comprising 4 total wt % of dinitrile compounds, between 0.8-5 total wt % of trinitrile compounds, and propyl propionate and that satisfies Formulas (1)-(2). Ex. 1005, ¶¶34-35. Moreover, this set of embodiments includes the best performing embodiment for each test disclosed in Hong. Embodiment 25 demonstrated the lowest thickness change rate in the high-temperature cycle test, and Embodiment 21 demonstrated the highest capacity retention rate in that same test. Ex. 1005, ¶¶30-31, 42. Embodiment 20 demonstrated the highest capacity retention rate and recovery rate in the high-temperature storage test, and Embodiment 13 demonstrated the lowest thickness change rate in that test. Ex. 1005, ¶¶30-31, 41-42. Each of

Embodiments 2-15, 18, 20-21, and 25 also protected against lithium precipitation during the low-temperature charge test. Ex. 1005, ¶¶30-31, 41-42.

334. In my opinion, a person of ordinary skill in the art would have been motivated to incorporate the electrolyte of Hong into the battery structure of Fujikawa in order to obtain the benefits described in both references. In my opinion, a person of ordinary skill in the art would have understood that the selection of battery structure and electrolyte are independent choices. In other words, a given battery structure does not require a particular electrolyte, and vice versa.

335. In my opinion, a person of ordinary skill in the art would have had a reasonable expectation of success in modifying the lithium secondary battery of Fujikawa to incorporate the electrolyte of Hong. Fujikawa discloses a method of preparing a lithium battery that would have been readily understood by a person of ordinary skill in the art. Ex. 1009, ¶¶64-69, 96-97. Similarly, Hong discloses a method of preparing an electrolyte that would have been readily understood by a person of ordinary skill in the art. Ex. 1009, ¶26. A person of ordinary skill in the art would have understood that Fujikawa's electrolyte manufacturing step could be replaced with Hong's electrolyte manufacturing method.

336. Moreover, Fujikawa considers the use of electrolytes having shared solvents and lithium salts, and additives intended for the same purpose as the electrolytes disclosed in Hong. Fujikawa discloses that the non-aqueous solvent may

include ethylene carbonate, propylene carbonate, and diethyl carbonate. Ex. 1009, ¶59. Fujikawa states that combined use of two or more solvents is preferred and particularly preferred is a “mixed solvent of a cyclic carbonate, a chain carbonate and an aliphatic carboxylic acid ester.” Ex. 1009, ¶59. Embodiments 2, 18, and 25 of Hong contain the cyclic carbonates ethylene carbonate and propylene carbonate, the chain carbonate diethyl carbonate, and the aliphatic carboxylic acid ester propyl propionate. Ex. 1005, ¶¶34-35.

337. Fujikawa also states that the lithium salt may be lithium hexafluorophosphate (LiPF_6) or a lithium imide salt, used singly or in any combination of two or more. Ex. 1009, ¶58. Fujikawa adds that the lithium salt concentration is “more preferably 0.5 to 1.5 mol/L.” Ex. 1009, ¶58. Embodiments 2 and 18 of Hong contain 1.1 M LiPF_6 , while Embodiment 25 of Hong contains 1.0 M LiPF_6 and 0.5 M of the lithium imide salt LiTFSI . Ex. 1005, ¶¶34-35.

338. Fujikawa further states that “[t]he non-aqueous electrolyte may further contain an additive so as to improve charge/discharge characteristics of the battery,” such as vinylene carbonate (VC) or vinyl ethylene carbonate (VEC). Ex. 1009, ¶60. Fujikawa explains that the additives “form a coating film on the positive and/or negative electrodes, which improves the stability during overcharge.” Ex. 1009, ¶60. Hong similarly states that “the tricyanophosphite compound or the tricyanophosphate compound contained in the electrolyte of the present invention

can form films on the surfaces of the positive and negative electrodes. . . thereby stabilizing the structure of the positive electrode, [and] improving the SEI film at the negative electrode.” Ex. 1005, ¶18. Embodiments 2 and 18 further contain VEC. Ex. 1005, ¶¶34-35.

339. In my opinion, a person of ordinary skill in the art would have a reasonable expectation of success in producing an operable battery by modifying the lithium secondary battery of Fujikawa to incorporate the electrolyte of Hong.

2. Claim 14

340. In my opinion, for the reasons discussed below, the combination of Fujikawa and Hong renders obvious claim 14 of the ’363 patent.

a. [14pre]: “The electrochemical device according to claim 13,”

341. In my opinion, the lithium-ion battery of Fujikawa modified to incorporate the electrolyte of Hong discloses an electrochemical device according to claim 13. In Examples 38 and 39, Fujikawa discloses an electrochemical device comprising electrodes. Ex. 1009, ¶¶96 (Example 38: “the positive and negative electrodes were placed such that the center exposed portions of the positive and negative electrodes faced each other as shown in” Figure 55 above), 97 (Example 39: “the positive and negative electrodes were placed such that the center exposed portions of the positive and negative electrodes faced each other as shown in” Figure

56 above). As explained in Section XI.A.8 above, Hong discloses the electrolyte recited in claim 13. As explained in Section XI.E.1 above, a person of ordinary skill in the art would have been motivated with a reasonable expectation of success to incorporate the electrolyte of Hong into the lithium secondary battery of Fujikawa.

b. [14.a]: “wherein the electrode comprises a current collector and a coating on the current collector,”

342. In my opinion, the combination of Fujikawa and Hong discloses an electrode comprising a current collector and a coating on the current collector. Fujikawa states that “[t]he positive electrode active material layer is preferably prepared by allowing a current collector to carry a material mixture comprising a positive electrode active material and a small amount of a binder.” Ex. 1009, ¶52. Fujikawa further states that “[t]he negative electrode active material may be deposited directly onto the current collector.” Ex. 1009, ¶54.

343. In the examples, Fujikawa discloses that the positive electrode was obtained by applying a positive electrode material mixture paste to the positive electrode current collector, and the negative electrode was obtained by applying a negative electrode material mixture paste to the negative electrode current collector. Ex. 1009, ¶¶65-66, 96-97, 89-91; *see also* ¶¶52-54.

c. [14.b]: “the coating comprising a single-sided coating and a double-sided coating, wherein: the single-sided coating is a coating formed by applying a slurry on one surface of the current collector; and the double-

sided coating is a coating formed by applying a slurry on two opposite surfaces of the current collector; and”

344. In my opinion, the combination of Fujikawa and Hong discloses electrodes with a coating comprising a single-sided coating and a double-sided coating.

345. Fujikawa discloses lithium secondary batteries in which a single-sided coating and a double-sided coating were formed on both the cathode and the anode. Ex. 1009, ¶¶64-66, 96-97, 89-91. Fujikawa states that the positive electrode paste “was applied onto each entire surface of a 15 μ m thick aluminum foil serving as a positive electrode current collector 12 except for a center exposed portion 12a.” Ex. 1009, ¶¶65, 96-97. Fujikawa thus discloses a cathode comprising a single-sided coating (opposite the center exposed portion 12a) and a double-sided coating, as shown in Figure 57 and Figure 58 below.

346. Fujikawa further states that the negative electrode paste was applied to both surfaces of the negative current collector except at a center exposed portion 22a. Ex. 1009, ¶¶66, 96-97, 89-91. Fujikawa thus discloses an anode comprising a single-sided coating (opposite the center exposed portion 22a) and a double-sided coating, as shown in Figure 57 and Figure 58 below.

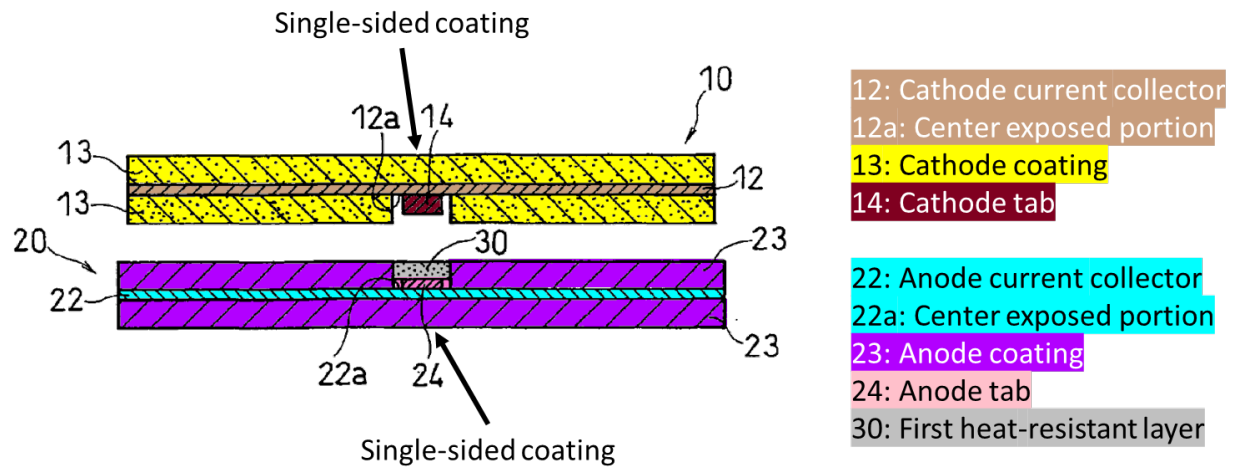


Figure 57: Battery of Fujikawa with One Heat-Resistant Layer on the Anode

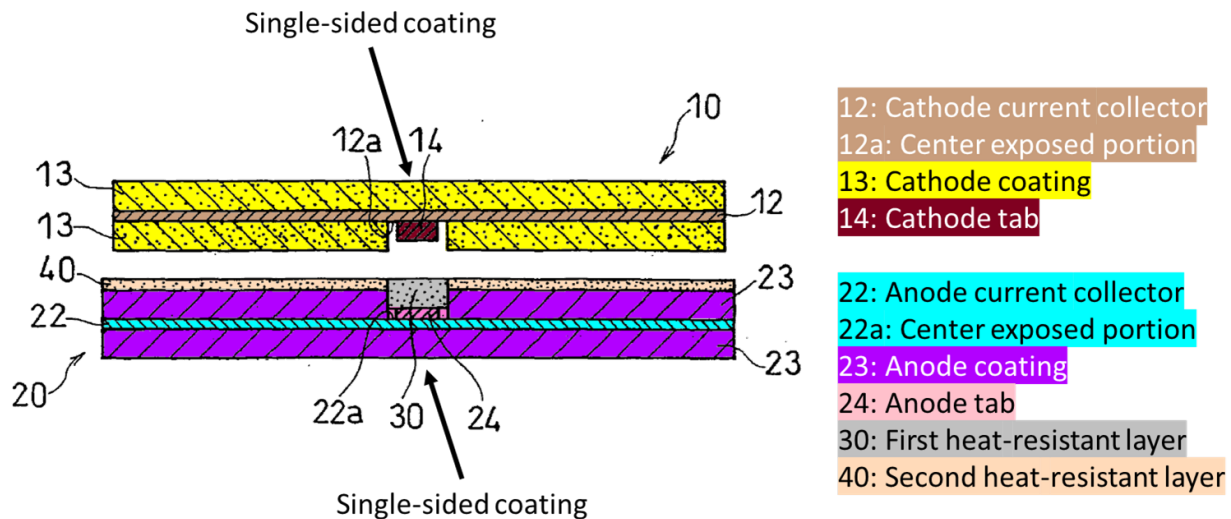


Figure 58: Battery of Fujikawa with Two Heat-Resistant Layers on the Anode

- d. [14.c]: “the electrode with the single-sided coating has an electrode compaction density D1, and the electrode with the double-sided coating has an electrode compaction density D2, wherein D1 and D2 meet the relationship: about $0.8 \leq D1/D2 \leq$ about 1.2.”

347. In my opinion, the combination of Fujikawa and Hong discloses electrodes having a ratio between the electrode compaction density for the single-

sided coating and the electrode compaction density for the double-sided coating that is within the claimed range. Fujikawa discloses that the positive electrode active material layers each “each hav[e] an active material density of 3.5 g/cm^3 .” Ex. 1009, ¶¶65, 96-97. Thus, for the cathode of Fujikawa, the single-sided coating has an electrode compaction density of 3.5 g/cm^3 ($D1 = 3.5 \text{ g/cm}^3$) and the double-sided coating has an electrode compaction density of 3.5 g/cm^3 ($D2 = 3.5 \text{ g/cm}^3$). Thus, for the cathode of Fujikawa, $D1/D2 = 1$, which falls within the range recited in claim 14 of the '363 patent.

348. Similarly, Fujikawa discloses that the negative electrode active material layers “each hav[e] an active material density of 1.6 g/cm^3 .” Ex. 1009, ¶¶66, 96-97, 89-91. Thus, for the anode of Fujikawa, the single-sided coating has an electrode compaction density of 1.6 g/cm^3 ($D1 = 1.6 \text{ g/cm}^3$) and the double-sided coating has an electrode compaction density 1.6 g/cm^3 ($D2 = 1.6 \text{ g/cm}^3$). Thus, for the anode of Fujikawa, $D1/D2 = 1$, which falls within the range recited in claim 14 of the '363 patent.

3. **Claim 15: “The electrochemical device according to claim 14, wherein the electrodes comprise a cathode and an anode, wherein when the electrode is a cathode, $3.5 \text{ g/cm}^3 \leq D2 \leq 4.3 \text{ g/cm}^3$; or when the electrode is an anode, $1.2 \text{ g/cm}^3 \leq D2 \leq 1.8 \text{ g/cm}^3$.”**

349. In my opinion, for the reasons discussed below, claim 15 of the '363 patent is obvious over the combination of Fujikawa and Hong.

350. In my opinion, the combination of Fujikawa and Hong discloses a cathode and an anode, each having a compaction density within the ranges recited in claim 15 of the '363 patent. As explained in Section XI.E.2.d above, Fujikawa discloses that the cathode has a compaction density of 3.5 g/cm³ and that the anode has a compaction density of 1.6 g/cm³. Ex. 1009, ¶¶64-66, 96-97, 89-91. These values fall within the ranges recited in claim 15 of the '363 patent.

F. Claim 16 Is Obvious over Hong

351. In my opinion, for the reasons discussed below, claim 16 of the '363 patent is obvious over Hong.

1. [16pre]: “An electronic device, comprising”

352. In my opinion, a person of ordinary skill in the art would have found it obvious to use the lithium secondary batteries disclosed in Hong, including Embodiments 2, 18, and 25, in an electronic device. Hong discloses that lithium secondary batteries “have been widely used in consumer electronic products, energy storage products, and power products,” and describes that use as an impetus for its invention. Ex. 1005, ¶2. A person of ordinary skill in the art would have known how to connect a lithium secondary battery to an electronic device to provide power. In my opinion, a person of ordinary skill in the art would have been motivated with a reasonable expectation of success to use the lithium secondary batteries disclosed in Hong in an electronic device.

2. **[16.a]-[16.h]: “an electrochemical device that includes electrodes and an electrolyte comprising a dinitrile compound, a trinitrile compound, and propyl propionate, wherein, based on a total weight of the electrolyte, a weight percentage of the dinitrile compound is X and a weight percentage of the trinitrile compound is Y, where X and Y meet conditions represented by Formula (1) and Formula (2): about 2 wt % $\leq$ (X+Y) $\leq$ about 11 wt % (1); and about 0.1 $\leq$ (X/Y) $\leq$ about 8 (2).”**

353. As explained in Section XI.A.9 above, in my opinion, Hong discloses an electrochemical device that includes electrodes and an electrolyte comprising a dinitrile compound, a trinitrile compound, and propyl propionate that satisfies Formulas (1) and (2).

XII. EXHIBITS

354. Exhibit 1010 is a true and accurate copy of a Material Safety Data Sheet for Adiponitrile from Sigma-Aldrich. Exhibit 1010 was downloaded under my supervision from Sigma-Aldrich’s website on January 27, 2023. Exhibit 1010 has a file name <https://www.sigmaaldrich.com/US/en/sds/aldrich/900020>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

355. Exhibit 1011 is a true and accurate copy of a Material Safety Data Sheet for Diethyl Carbonate from Sigma-Aldrich. Exhibit 1011 was downloaded under my supervision from Sigma-Aldrich’s website on January 27, 2023. Exhibit 1011 has a file name <https://www.sigmaaldrich.com/US/en/sds/aldrich/d91551>. Both persons

of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

356. Exhibit 1012 is a true and accurate copy of a Material Safety Data Sheet for Ethylene Glycol Bis(propionitrile) Ether from Tokyo Chemical Industry. Exhibit 1012 was downloaded under my supervision from Tokyo Chemical Industry's website on January 27, 2023. Exhibit 1012 has a file name tcichemicals.com/US/en/p/E0108. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

357. Exhibit 1013 is a true and accurate copy of a Material Safety Data Sheet for 1,3,2-Dioxathiolane-2,2-Dioxide (Ethylene Sulfate/DTD) from Sigma-Aldrich. Exhibit 1013 was downloaded under my supervision from Sigma-Aldrich's website on January 27, 2023. Exhibit 1013 has a file name <https://www.sigmaaldrich.com/US/en/sds/aldrich/471690>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

358. Exhibit 1014 is a true and accurate copy of a Material Safety Data Sheet for Ethylene Carbonate from Sigma-Aldrich. Exhibit 1014 was downloaded under my supervision from Sigma-Aldrich's website on January 27, 2023. Exhibit 1014 has a file name <https://www.sigmaaldrich.com/US/en/sds/aldrich/e26258>. Both

persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

359. Exhibit 1015 is a true and accurate copy of a Material Safety Data Sheet for Fluoroethylene Carbonate from Sigma-Aldrich. Exhibit 1015 was downloaded under my supervision from Sigma-Aldrich's website on January 27, 2023. Exhibit 1015 has a file name <https://www.sigmaaldrich.com/US/en/sds/aldrich/757349>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

360. Exhibit 1016 is a true and accurate copy of a Material Safety Data Sheet for 1,3,6-Hexanetricarbonitrile from Sigma-Aldrich. Exhibit 1016 was downloaded under my supervision from Sigma-Aldrich's website on January 27, 2023. Exhibit 1016 has a file name <https://www.sigmaaldrich.com/US/en/sds/aldrich/419257>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

361. Exhibit 1017 is a true and accurate copy of a Material Safety Data Sheet for Lithium Hexafluorophosphate (LiPF_6) from Sigma-Aldrich. Exhibit 1017 was downloaded under my supervision from Sigma-Aldrich's website on January 27,

2023. Exhibit 1017 has a file name

<https://www.sigmaaldrich.com/US/en/sds/aldrich/450227>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

362. Exhibit 1018 is a true and accurate copy of a Material Safety Data Sheet for Bis(trifluoromethane)sulfonimide Lithium Salt (LiTFSI) from Sigma-Aldrich. Exhibit 1018 was downloaded under my supervision from Sigma-Aldrich's website on January 27, 2023. Exhibit 1018 has a file name <https://www.sigmaaldrich.com/US/en/sds/aldrich/15224>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

363. Exhibit 1019 is a true and accurate copy of a Material Safety Data Sheet for Propylene Carbonate from Sigma-Aldrich. Exhibit 1019 was downloaded under my supervision from Sigma-Aldrich's website on January 27, 2023. Exhibit 1019 has a file name <https://www.sigmaaldrich.com/US/en/sds/sial/310328>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

364. Exhibit 1020 is a true and accurate copy of a Material Safety Data Sheet for Propyl Propionate from Sigma-Aldrich. Exhibit 1020 was downloaded under my supervision from Sigma-Aldrich's website on January 27, 2023. Exhibit 1020 has a

file name <https://www.sigmaaldrich.com/US/en/product/aldrich/112267>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

365. Exhibit 1021 is a true and accurate copy of a Material Safety Data Sheet for 1,3-Propanesultone from Sigma-Aldrich. Exhibit 1021 was downloaded under my supervision from Sigma-Aldrich's website on January 27, 2023. Exhibit 1021 has a file name <https://www.sigmaaldrich.com/US/en/sds/aldrich/291250>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

366. Exhibit 1022 is a true and accurate copy of a Material Safety Data Sheet for Succinonitrile from Sigma-Aldrich. Exhibit 1022 was downloaded under my supervision from Sigma-Aldrich's website on January 27, 2023. Exhibit 1022 has a file name <https://www.sigmaaldrich.com/US/en/sds/aldrich/160962>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

367. Exhibit 1023 is a true and accurate copy of a Material Safety Data Sheet for Propanephosphonic Acid Anhydride from Sigma-Aldrich. Exhibit 1023 was downloaded under my supervision from Sigma-Aldrich's website on January 27,

2023. Exhibit 1023 has a file name <https://www.sigmaaldrich.com/US/en/sds/mm/8.43943>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

368. Exhibit 1024 is a true and accurate copy of a Material Safety Data Sheet for 4-Vinyl-1,3-Dioxolan-2-one (Vinylethylene Carbonate) from Sigma-Aldrich. Exhibit 1024 was downloaded under my supervision from Sigma-Aldrich's website on January 27, 2023. Exhibit 1024 has a file name <https://www.sigmaaldrich.com/US/en/sds/aldrich/496820>. Both persons of ordinary skill in the art and experts in the field regularly rely on Material Safety Data Sheets as a reliable authority on the physical properties of a given compound.

369. Exhibit 1027 is a true and accurate copy of a Table of Properties for Common Solvents Used in Organic Chemistry from the American Chemical Society (ACS) Division of Organic Chemistry. Exhibit 1027 was downloaded under my supervision from the ACS website on February 14, 2023. Exhibit 1027 has a file name <https://organicchemistrydata.org/solvents/>. Both persons of ordinary skill in the art and experts in the field rely on the American Chemical Society as a reliable authority on the physical properties of a given compound.

XIII. CONCLUSION

370. For the reasons set forth above, it is my opinion that challenged claims 1-16 of the '363 patent are anticipated or rendered obvious by the prior art.

371. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true. I further declare that all statements made herein were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code.

372. In signing this declaration, I understand that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross examination in the case and that cross examination will take place within the United States. If cross examination is required of me, I will appear for cross examination within the United States during the time allotted for cross examination.

DATE: February 23, 2023

By: Menahem Anderman
Menahem Anderman, Ph.D.

Appendix A

Menahem Anderman, PhD

HIGHLIGHTS: A broad-based battery industry consultant with experience ranging from materials research, cell design, and product development, to manufacturing, market, and business development and management. Well connected to material developers, battery producers, and automotive-battery users on three continents. Distinguished within the industry by a combination of technical depth and business and market comprehension.

Professional History

TOTAL BATTERY CONSULTING, INC., Oregon House, CA 1996 - present

Founder and President

Total Battery Consulting, Inc. is a private firm that offers consulting services to the battery and associated industries, specializing in Li-based battery development, technology, cost, and market assessments, battery-system selection, and battery-related equity investment, licensing, and legal work.

Dr. Anderman is the author of the Total Battery Consulting Industry Report (formerly published by Advanced Automotive Batteries): a biennial assessment of technology and market trends in energy storage for electrified vehicles. In this capacity, Dr. Anderman meets with all major international automakers at least annually to discuss technology and market development trends. The Report, which has been purchased by over 240 organizations, is considered by many to be a reference book for the industry.

ADVANCED AUTOMOTIVE BATTERIES 2000 - 2015

(A division of Total Battery Consulting, Inc.)

Founder and President

In 2001, Dr. Anderman founded Advanced Automotive Batteries, as a division of Total battery Consulting, to produce the Advanced Automotive Battery Conference (AABC), and has chaired and created the AABC agenda ever since. AABC is widely considered to be the industry's foremost annual conference on energy storage for advanced vehicles. Dr. Anderman is responsible for the conference growth which, at its peak in 2011, reached 1600 delegates between the two annual events, AABC and AABC Europe. In 2015, AABC was bought by Cambridge EnerTech (CET). Dr. Anderman continues in his role as conference chairman and main creator of the technical program.

POLYSTOR CORPORATION, Dublin, CA 1997 - 1999

Vice President of Technology

Overall responsibilities for all technical areas of this start-up Li-Ion battery developer and producer, leading a group of 45 scientists, engineers, and technicians.

Led the design of 18650 cell and qualification by major customers, enabling PolyStor to be the first non-Japanese company to ship Li-Ion cells in volume. Directed the development and transfer to production of the first commercial Li-Ion (prismatic) cell featuring a LiNiCoO_2 cathode. The product exhibits the highest energy density in the industry and passes all IEC and UL tests. Won a \$9.5M hybrid-vehicle battery contract and directed the development work. Conducted trade of analysis and initiated development work of pouch ('polymer') Li-Ion cell.

ACME ELECTRIC CORPORATION, Tempe, AZ 1988 - 1996

Vice President and General Manager, Aerospace Division

Complete P&L responsibility, including technology, operation, marketing, and finance of a fully integrated division. Responsible for the consolidation of two separate operations into one facility. Oversaw market introduction of five new products in two years. Led the division to profitability.

Technical Director, Advanced Energy System Division

Overall technical responsibility for the design, development, and transfer to production of a new line of sealed Ni-Cd cells for the aviation market. The product featured the highest specific power and cycle life in the industry. Responsible for winning production contracts on the newest aircrafts including the Boeing 777, and for the only successful worldwide introduction of a sealed Ni-Cd battery as the main engine starting aircraft battery. Co-invented and directed the development of a sealed Ni-Cd battery incorporating flooded cells. Developed and qualified a space cell design that has outperformed all previous Ni-Cd space batteries.

W. R. GRACE AND COMPANY, Research Division, Columbia, MD 1983 - 1988

Project and Group Leader - Rechargeable Lithium Battery

Scaled up laboratory cells into fully packaged AA cells. Co-responsibility for a detailed business plan that assessed W.R. Grace's options to commercialize its rechargeable lithium battery technology. The cells designed exceeded state-of-the-art performance for rechargeable consumer batteries. Initiated safety testing.

Research Chemist

Assessed business opportunities for the company in existing and developing battery technologies. Developed unique plastic-bonded electrodes and a process to fabricate them. Developed the technical concept for electrode/separator laminates that formed the base of the Li polymer (gel) cells of the 1990s. Developed prototypes of spirally wound Li-TiS₂ cells and won U.S. Army development contract. Was granted seven U.S. and several international patents in electrode and battery technology.

UNIVERSITY OF CALIFORNIA SANTA BARBARA, CA 1980 - 1983

Research Associate

Studied the photoelectrochemical activity of doped iron oxide electrodes. Developed a P-N junction photoelectrochemical cell that converted solar energy into hydrogen.

Education

Selective Executive Training

- 1996 Demand Flow Technology, JIT Institute of Technology
- 1995 TQM, University of Phoenix
- 1995 Developing Corporate Core Competence, Lahote Executive Training
- 1994 Finance and Accounting for Non-financial managers, University of Pennsylvania
- 1994 Market Segmentation, Lahote Executive Training
- 1993 Creating Share Holder Value, Alcar Institute
- 1992 Robust Design (Taguchi), American Supply Institute

Ph.D. Physical Chemistry:

University of California, Santa Barbara, 1980 to 1983
GPA 4.0. Nominee for Electrochemistry Graduate Research Award.
Thesis: "Photoelectrochemistry On Doped Iron Oxide Electrodes"
Multidisciplinary course work included courses in Physical Chemistry, Electrochemistry, Solid Electrolytes, Solid State Physics, and Photochemistry.

B.Sc., Chemistry:

Hebrew University, Jerusalem, Israel, 1976 to 1978
GPA 3.8. Dean's List all three years. Completed all requirements in three years.

Other:

Israel Defense Forces (IDF). Special Forces, Parachute, 1971 to 1975

Publications

1. "The 2019 xEV Industry Insider Report – Assessing the Future of Hybrid and Electric Vehicles", April 2019 Edition
2. "xEV Market Expansion", AABC 2019, San Diego, CA (June 2019)
3. "2025 xEV Battery Characteristics", AABC Europe 2019, Strasbourg, France (January 2019)
4. "xEV Market Expansion", AABC Europe 2019, Strasbourg, France (January 2019)
5. "What is EV Battery Technology likely to look like in 2025?", AABC 2018, San Diego, CA (June 2018)
6. "xEV Architecture Directions in the Major World Markets", AABC 2018, San Diego, CA (June 2018)
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Client List (2000-2016)

Automakers

- Adam Opel
- Audi AG
- BMW
- Chrysler LLC
- DaimlerChrysler
- Fiat Auto
- Fisker Automotive
- Ford Motor Co.
- Fuji Heavy Industries
- General Motors
- Harley-Davidson Motor Company
- Honda R&D
- Hyundai Motor Co.
- Mercedes Benz R&D
- Nissan
- Porsche
- Renault
- Toyota
- Volkswagen
- Volvo

Automotive System Suppliers

- Alcoa
- AVL
- BAE Systems
- Ballard Power Systems
- BorgWarner
- Caterpillar
- Continental TEMIC
- Cummins, Inc.
- Dana Holding Corporation
- Delphi
- Denso Corporation
- Eaton Corporation
- Electro Power Systems, S.p.A.
- General Electric Co.
- Robert Bosch
- Siemens AG
- TEMIC Automotive Electric Motors
- Visteon Corporation

Financial Institutions

- Alliance Bernstein LP
- Ardsley Partners
- Arsenal Capital
- Baillie Gifford
- Bank of America Merrill Lynch
- Bessemer Venture Partners

- Blue Ridge Capital
- Bright Path Capital Partners
- Capital Group Research
- Capital International
- CityGroup
- Colmobil, Ltd.
- Credit Suisse
- CRI Advantage
- Crosslink Capital
- David Gelbaum
- Deutsche Bank
- Deutsche Bank Asia AG
- Endeavour Capital
- Enerjisa Enerji A.S.
- Franklin Templeton Investments
- Generation Investment Management, LLP
- Global Venture Investments
- Goldman Sachs
- Harpers International
- Impala Asset Management LLC
- Ivory Investment Management
- Janus
- J.P. Morgan
- Jefferies & Company
- Joho Capital, LLC
- L-Gam Advisers LLP
- Legend Holdings Limited
- Marathon Resource Investments
- Marsfield
- Marsico Capital
- Marubeni Corporation
- Mason Capital
- MFS Investment Management
- Mitsui & Co., Ltd.
- Miura Global Management
- Morgan Stanley
- Santa Barbara Asset Management
- Scout Capital
- Select Equity Group
- Soros Strategic Partners LP
- T. Rowe Price
- Third Point LLC
- Townsend Capital, LLC
- Trust Company of the West
- UBS Global Asset Management
- Valiant Capital Partners
- Water Street Capital
- Wellington Management

- ZBI Ventures

Battery and Ultracapacitor Producers

- 24M Technologies
- A123Systems
- Altair Nanotechnologies
- Automotive Energy Supply Corporation
- BatScap Bolloré
- Boston Power
- Cobasys
- Compact Power
- Dow Kokam
- East Penn Manufacturing
- Electro Energy
- Energy Conversion Devices
- EPCOS
- Farasis Energy, Inc.
- Furukawa Battery Co.
- GAIA Akkumulatorenwerke
- GP Batteries International
- Hitachi America, Ltd.
- Hitachi Maxell
- Hitachi Vehicle Energy
- HTTM LLC
- Hunan Corun New Energy Co., Ltd.
- Johnson Controls Saft
- Leyden Energy
- LG Chem
- Lithium Technology
- Magna E-Car Systems
- Matsushita Battery Industrial Co.
- Maxwell Technologies
- NEC Lamilion Energy
- Nichicon America Corporation
- Nippon Chemi-Con Corporation
- Panasonic EV Energy
- Polyplus Battery Company
- Reserve Power Cell
- Saft
- Samsung Display Devices Co.
- SB LiMotive GmbH
- Shin-Kobe Electric Machinery
- Sion Power Corporation
- SK Energy
- SK Innovation
- SolidEnergy Systems
- Sony Energy Devices Corporation
- Techno Core Co., Ltd.
- Toshiba

- Valence Technology
- Varta Batteries
- Vulcan
- ZincFive

Materials Makers

- Air Products and Chemicals
- Amtek Research
- Applied Materials, Inc.
- Arkema
- Asahi Glass
- BASF Corporation
- Brueckner Maschinebau GmbH & Co. KG
- Cabot Corporation
- Celgard
- Chemetall
- ConocoPhillips Company
- Corning
- Degussa
- Dow Chemical Company
- DuPont Company
- Engelhard Corporation
- Entegris
- Freudenberg & Co.
- Hanwha Chemical R&D Center
- Hollingsworth & Vose
- Honeywell
- Imerys Graphite & Carbon
- INCO Special Products
- Kimberly-Clark
- MeadWestvaco Corporation
- Merck KGaA
- Michelin
- Mitsubishi Chemical Corporation
- Mitsui Mining & Smelting Co., Ltd.
- Momentive
- Morgan Crucible
- Nanogram
- NGK-Locke, Inc.
- Occidental Material Group (OMG)
- Orion
- POSCO
- Primet Precision Materials
- Rogers Corporation
- Rohm and Haas Chemicals
- Rio Tinto
- Sabic Innovative Plastics
- Schott AG
- SciMAT

- SGL Carbon
- Showa Denko
- Solvay
- SQM S.A.
- Süd Chemie
- Sumitomo Bakelite North America
- Sumitomo Corporation
- Ticona
- Toda
- Tonen Chemical
- Toray Battery Separator Film
- Umicore
- W.L. Gore & Associates
- Zeon Corporation

Oil Companies

- BP America Production Company
- Chevron Texaco Corporation
- Exxon Mobil Chemical Co.
- Nippon Oil (U.S.A.)
- Nippon Shokubai Co.
- Shell Oil
- SK Corporation

Other

- Acme Electric Corporation
- ALD NanoSolutions
- **Amster, Rothstein & Ebenstein**
- Andreas STIHL AG & Co KG
- **Andrews Kurth LLP**
- Argonne National Laboratory
- ATS Armor LLC
- Battery Design Company
- Boeing / Hughes Space & Communications
- BTU International
- California Air Resources Board
- Copper Development Association
- CRA International
- CRI Advantage
- E-Motion Mobility
- Electric Power Research Institute
- **Eimer Stahl LLP**
- EnBW Energie Baden-Wuerttemberg AG
- Exponent
- Field Support Services
- Fraunhofer Institute for Systems and Innovation Research
- GE Global Research

- **Haynes & Boone LLP**
- Hon Hai Precision Ind. Co., Ltd.
- ICCT
- Idaho National Engineering and Environmental Laboratory
- IFP Energies Nouvelles
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- Instituto de Tecnologia Edson Mororo Moura
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- New York University
- Nickel Institute
- **Oblon**
- Philips Research Laboratories
- Procter & Gamble
- Ridgetop Research, LLC
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- SVP Japan Co.
- Taiwan Industrial Technology Research Institute (ITRI)
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- Voltaic Systems
- VTT Technical Research
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