

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

IPR2023-00586
Patent 10,833,363

DECLARATION OF VICTOR R. KOCH, Ph.D., IN SUPPORT
OF PATENT OWNER'S PRELIMINARY RESPONSE

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I. INTRODUCTION

1. I have been retained by Ningde Amperex Technology Ltd. (“ATL” or “Patent Owner”) as an independent technical expert in this proceeding before the United States Patent and Trademark Office (“PTO”) Patent Trial and Appeal Board (“PTAB”) regarding U.S. Patent No. 10,833,363 (the “’363 Patent”).

2. I understand that Zhuhai CosMX Battery Co., Ltd. (“Petitioner”) filed a petition for Inter Partes Review of the ’363 Patent (“Petition”), in which Petitioner asserts that:

- Claims 1-6, 11, 13, and 16 are anticipated by Chinese Patent No. 106848381 (“Hong” or “Ex. 1005”) (Ground 1);
- Claims 7-9 are obvious over Hong and U.S. Patent App. Pub. No. 2017/0084956 (“Zhuang” or “Ex. 1006”) (Ground 2);
- Claims 10 is obvious over Hong and U.S. Patent No. 6,544,685 (“Kim ’685” or “Ex. 1007”) (Ground 3);
- Claims 12 is obvious over Hong and U.S. Patent App. Pub. No. 2017/0069934 (“Kim ’934” or “Ex. 1008”) (Ground 4);
- Claims 14-15 are obvious over U.S. Patent App. Pub. No. 2007/0172736 (“Fujikawa” or “Ex. 1009”) and Hong (Ground 5)
- Claims 16 is obvious over Hong

3. I have been asked, for purposes of Patent Owner's Preliminary Response, to analyze and respond to Petitioner's assertion that claim 1 is anticipated by Hong (Ground 1). I reserve the right to analyze and respond to other alleged patentability challenges if this proceeding is instituted.

4. As explained below, in my opinion, the Petition fails to show that claim 1 of the '363 Patent is anticipated.

5. I am being compensated at my customary consulting rate of \$750 per hour. My compensation is in no way contingent on the nature of my opinions or the outcome of this or any other proceeding. I have no other interest in this proceeding.

II. BASIS FOR OPINIONS

A. Qualifications

6. My qualifications and professional experience are described in my curriculum vitae, a copy of which is provided with this Declaration as Ex. 2002. The following is a brief summary of my qualifications and professional experience.

7. I am a researcher and consultant in the fields of chemistry and organic electrochemistry, with a focus on electrolytes for lithium ion batteries and room temperature ionic liquid materials. I received a B.S. in Chemistry from the University of Illinois in 1966, and a Ph.D. from Colorado State University in Organic Electrochemistry in 1973.

8. My Ph.D. thesis involved the study of oxidation of various organic compounds in acetonitrile on a platinum electrode, identification of the oxidation products, and identification of the reaction mechanisms, and led to three publications in peer-reviewed journals as listed in my CV.

9. Following my Ph.D., I served as a post-doctoral fellow at Colorado State University where I synthesized and characterized a number of novel, thermally stable ionic liquids, which also led to several publications in peer-reviewed journals as listed in my CV. These materials were subsequently studied by the U.S. Navy for applications as novel, high temperature battery electrolytes.

10. After concluding my post-doctoral fellowship, I worked at EIC Laboratories from 1975 to 1981, where I developed a new technique to purify the organic solvent 2-methyltetrahydrofuran, which was found to stabilize lithium metal electrodes in a lithium hexafluoroarsenate/2-methyltetrahydrofuran electrolyte. Rather than generating lithium dendrites on the electrodes when charged in, for example, propylene carbonate-based electrolytes, I was able to deposit reflective mirror-like lithium metal deposits on a nickel substrate from a lithium hexafluoroarsenate/2-methyltetrahydrofuran electrolyte. This discovery led to U.S. Pat. No. 4,118,550 followed by several peer-reviewed publications as listed in my CV.

11. In 1981 I founded Covalent Associates, Inc. (“Covalent”) where I directed and participated in research and development on all aspects of lithium-ion battery technology, including electrolytes, separators, and anode and cathode materials. During the 1980s, 1990s, and into the 2000s, I served as the principal investigator on forty federally funded research contracts and grants, of which the following eleven focused on the development of advanced lithium ion batteries, including novel anode and cathode materials and novel electrolyte formulations:

- Dilithium Squarate: A Novel Supporting Electrolyte for Lithium Batteries.
- Thermally Stable Supporting Electrolytes for Rechargeable Lithium Batteries.
- Novel, Stable, Non-Complexing Anions for Rechargeable Lithium Batteries.
- Overcharge Protection Additives for Rechargeable Lithium Batteries.
- New Turbostratic Mesocarbon Microbeads and Low Temperature Electrolytes for $\text{Li}_x\text{C}_6/\text{Li}_x\text{CoO}_2$ Cells.
- Highly Conductive Polymer Electrolytes for Rechargeable Li Batteries.
- Halogenated Solvents for Non-Flammable Lithium Ion Battery Electrolytes.
- Advanced Polymer Electrolytes for Lithium-ion Batteries.
- Non-Flammable Lithium-ion Battery Electrolytes Capable of Extended Operational Temperatures.

- Novel Electrolyte for -100°C Lithium Battery Application.
- New Non-aqueous Electrolyte Components Salts and Solvents.

12. In addition to the work noted above, my colleagues at Covalent and I also discovered, patented and published papers on an entirely new family of hydrophobic (*i.e.*, water immiscible) ionic liquid materials with unique and improved physical, chemical, and electrochemical properties, including materials that function as improved film-forming additives in lithium-ion battery electrolytes.

13. In 1995, while on an “industrial sabbatical” at Oregon State University, I served as a research professor in the Department of Chemistry and Materials Science, where I successfully perfluorinated several of Covalent’s patented ionic liquid materials. The ionic liquids were dissolved in liquid hydrofluoric acid and then exposed to fluorine gas on a fluorine line. During my time at Oregon State University, I also directed the research group of a colleague professor while he was away on sabbatical. While I directed this research group, the group’s Ph.D. students undertook the intercalation of quaternary ammonium salts into graphite anodes in order to study the degree of expansion of graphitic galleries via X-ray diffraction spectroscopy. These studies were directed at understanding the feasibility of sodium-ion batteries employing graphite anode materials.

14. From 2018 through 2020 I designed, prepared, and further developed ultra-high rate lithium ion battery electrolyte formulations under U.S. Department of Energy-funded contract led by Stanford University. Under this program, ionic liquid additives were added to novel low viscosity base electrolytes to improve high rate lithium-ion test cells.

15. Taken together, my eleven lithium-ion battery electrolyte programs completed at Covalent in addition to the Stanford University electrolyte program represent approximately 25 years of in-depth, hands-on experience in the design, preparation and optimization of electrolyte solutions and components.

B. Materials Considered

16. The opinions contained in this Declaration are based on the documents I reviewed, as well as my education, years of professional experience, and knowledge. In forming my opinions expressed in this Declaration, I further reviewed the Petition, all exhibits or other material cited therein, and any additional exhibits or other material cited in this declaration.

17. This Declaration presents the opinions I have formed at the present time, and I reserve the right to revise, supplement, or amend my opinions stated in this Declaration based on any new information that I may be asked to review.

III. LEGAL STANDARDS

18. In this section, I describe my understanding of certain legal standards. I have been informed of these legal standards by Patent Owner's legal counsel. I am not an attorney and I am relying only on instructions from Patent Owner's legal counsel for these legal standards.

A. Claim Construction

19. My opinions concern what I believe the person of ordinary skill in the art ("POSA") would have understood the meaning of certain claim terms to be based on the patent documents.

20. I have been informed that assessing the validity of a patent claim requires a two-step analysis. The first step involves the proper interpretation or construction of the claim language in order to determine its scope and meaning. The second step requires comparing the claim, as properly construed, to the alleged prior art to determine whether the limitations of the claim are met by the prior art.

21. My methodology for determining the meaning of claim phrases was first to study the patent carefully. In particular, I studied the claims themselves, followed by the background, detailed specification, figures, and other patent content. Next, I reviewed the prosecution history looking for any clarifications or limitations that might be attached to claim terms. In some circumstances, I looked at other documents, such as references applied by the patent office.

22. I understand that in a *inter partes* review, claim terms are to be given their ordinary and customary meaning as understood by a person of ordinary skill in the art in the context of the entire disclosure at the time of the invention. I understand that one must be careful not to read a specific embodiment appearing in the written description into the claim if the claim language is broader than the embodiment. I further understand that any special definition for a claim term must be set forth with reasonable clarity, deliberateness, and precision.

23. I have been informed that this standard is the same as that used in United States district courts, in which claim terms are given their ordinary and customary meaning as would be understood by a person of ordinary skill in the art at the time of the invention having taken into consideration the language of the claims, the specification, and the prosecution history of record under the *Phillips* claim construction standard.

B. Prior Art Status

24. I understand that the “priority date” of a patent is the date on which it is filed, or the date on which an earlier-filed patent application is filed if the patentee claims the benefit of priority to that earlier-filed patent application. I understand that a particular claim is entitled to claim the priority date of an earlier-filed application if the earlier-filed application provides written description of the subject matter of that particular claim.

25. I understand that a U.S. or foreign patent or patent application qualifies as prior art to an asserted patent if the date of issuance or publication of the patent or publication is prior to the priority date of the challenged patent.

26. I understand that a printed publication, such as an article published in a magazine or trade publication, qualifies as prior art to the challenged patent if the date of publication is prior to the priority date of the asserted patent.

27. I understand that to qualify as prior art, a reference must contain an enabling disclosure that allows one of ordinary skill to practice the reference's disclosure without undue experimentation.

C. Anticipation

28. I understand that, once the claims of a patent have been properly construed, determining anticipation of a patent claim requires a comparison of the properly construed claim language to the prior art on a limitation-by-limitation basis.

29. I understand that in order for a claim to be anticipated, each and every requirement of the claim must be found, expressly or inherently, in a single prior art reference as recited in the claim.

30. I understand that a prior art reference "inherently" discloses a limitation if that limitation is necessarily present in the prior art reference.

31. I understand, however, that inherency may not be established by probabilities or possibilities, and the mere fact that a certain thing may result from a given set of circumstances is not sufficient to establish anticipation by inherency.

32. I understand that it is impermissible for anticipation to combine multiple, separate embodiments, even if they are described in a single prior art reference.

D. Obviousness

33. I understand that a claimed invention is not patentable if the claimed invention would have been obvious to a person of ordinary skill in the field of the invention at the time of the patent claim's effective filing date.

34. I have been informed and understand that the obviousness analysis requires evaluating the claim language as a whole, including comparing each and every limitation of the properly construed claim language to the prior art.

35. I understand that a person of ordinary skill in the art provides a reference point from which the prior art and claimed invention should be viewed. This reference point prevents one from using his or her own insight or hindsight in deciding whether a claim is obvious.

36. I understand that in order to show obviousness based on a single reference or a combination of references, a particular motivation to modify the

reference or combine the teachings in the references, and a reasonable expectation of success must be shown.

37. I understand that the obviousness inquiry includes consideration of various factors, such as the scope and content of the prior art, the differences between the prior art and the claims at issue, the knowledge of a person of ordinary skill in the pertinent art at the time of invention, and any objective factors indicating non-obviousness.

38. I am informed that objective factors indicating non-obviousness, also known as secondary considerations, may include (1) a long felt but unmet need in the prior art that was satisfied by the alleged invention of the patent; (2) commercial success or lack of commercial success of processes covered by the patent; (3) unexpected results achieved by the alleged invention; (4) praise of the alleged invention by others skilled in the art; (5) taking of licenses under the patent by others; and (6) deliberate copying of the alleged invention. I also understand that there must be a relationship or nexus between any such secondary indicia and the alleged invention.

39. I understand that in order to rely on a reference for obviousness, the reference must be analogous art. I also understand that to be analogous art, the reference must be either (1) from the same field of endeavor as the claimed subject matter, regardless of the problem addressed, or (2) if not in the same field of

endeavor, reasonably pertinent to the particular problem with which the inventor is involved. I am also familiar with the premise that for a reference to be reasonably pertinent, it must have logically commended itself to an inventor's attention at the time of invention.

IV. TECHNOLOGY OVERVIEW

A. Solid Electrolyte Interphase in Lithium-Ion Batteries

40. In lithium-ion batteries, lithium ions shuttle back and forth between the negative and positive electrodes during cycling. During the first charge of the lithium-ion battery the electrolyte undergoes reduction at negative electrode (or anode), and oxidation at the positive electrode (or cathode). This forms a passive protective layer on the anode and cathode called the solid electrolyte interphase (SEI), comprising a mixture of inorganic and organic electrolyte decomposition products. Battery performance, irreversible charge loss, rate capability, cyclability, and safety are highly dependent on the quality of the SEIs.

41. Many vital, interdependent factors contribute to properties of the SEI and there is no absolute parameter circumscribing the SEI. It is the combined effect of all these factors which affects the properties, quality, and efficiency of SEI. In particular, the specific type of solvent, organic additives, and lithium salt(s) added to the electrolyte solution, and the specific concentration each such component, can play a crucial role in determining the performance of the SEI.

42. While anode SEIs have been studied for over two decades, cathode SEIs have not been studied as much, and constitute a relatively new and “hot” area of research today. In particular, cathode SEIs that do not decompose and perform well at voltages above 4.4V are an area of high interest in industry and academia.

43. In a sense, designing and creating an ideal protective SEI is akin to playing a game of electrochemical Tetris. One needs to reduce on the anode material or oxidize on the cathode material those electrolyte solvent molecules and/or additive molecules in the “right” sequence and at the “right” potential in order to confer high cycle life at high voltages for a lithium-ion battery.

B. The '363 Patent

44. The '363 Patent describes a novel lithium-ion battery electrolyte solution that can provide a firm protective SEI film on the surface of the cathode of an electrochemical device such as a lithium-ion battery that is not easily decomposed, effectively inhibits the increase in DC internal resistance of the lithium ion battery, and achieves high capacity density, and excellent cycle and storage performances. Ex. 1001, 1:49-56, 3:1-13. The '363 Patent achieves this by providing an electrolyte solution comprising a compound comprising a dinitrile compound, a trinitrile compound, and propyl propionate in specific wt % concentrations. *Id.* 1:49-56, 27:55-61.

45. The '363 Patent explains that a dinitrile compound can form a protective film (or SEI)¹ on the cathode of the electrochemical device, so as to inhibit the decomposition of the electrolyte solvent in the electrochemical device. *Id.* 1:43-46. However, since the protective film itself is decomposed on the surface of the cathode at a high potential, the protective film's role of inhibiting decomposition of the solvent cannot be sustained for a long time. *Id.* 1:46-49.

46. The '363 Patent discusses the challenges with electrochemical devices working at voltages above 4.4V, noting that “[a]t a high voltage, the oxidizability of the cathode material is increased, and the stability is lowered, which makes the electrolyte easily decompose on the surface of the positive electrode or results in deterioration of the materials of the electrochemical device, so that the capacity of the electrochemical device is decreased.” *Id.* 21:52-57, 1:24-34; *see also* 1:26-31 (“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.”). The '363 Patent further explains that “[p]rior to the present application, the primary solution [was] to add a

¹ The “protective film” described in the '363 Patent is akin to the “SEI” described in Section IV.A.

film-forming additive to the electrolyte [but] doing so will cause an increase in the DC internal resistance of the battery, thereby resulting in a decrease in the cycle performance and a decrease in the capacity retention rate.” *Id.* 21:57-62.

47. The inventors of the '363 Patent discovered that by using a mixture of a dinitrile compound, a trinitrile compound and propyl propionate in specific concentration ranges, a firm SEI protective film that is not easily decomposed at a high potential of 4.45 V, and inhibit a DC internal resistance in the electrochemical device, could be formed on the surface of the cathode. *Id.* 1:49-54 (“The present inventors unexpectedly found that by using a mixture of a dinitrile compound, a trinitrile compound and propyl propionate, a firm protective film which is not easily decomposed on the surface of the cathode at a high potential can be formed. The electrolyte according to the embodiment of the present application can effectively inhibit the increase in DC internal resistance of the electrochemical device.”), 27:50-55 (“The combination of [a dinitrile, a trinitrile, and propyl propionate as specified in Table 2] can form a cathode protection film so as to reduce the side reactions, thereby effectively controlling the polarization and side reactions of the battery.”), 27:55-61 (“The ratio of the content of the trinitrile compound to the content of propyl propionate has great effect on the change in DC internal resistance of the battery. When Y/Z is within the range of 0.01-0.3, a better inhibition effect on the increase in DC internal resistance is achieved.”).

48. The '363 Patent explains that such a protective film inhibits side reactions in the lithium ion battery and reduces a voltage drop during storage of the lithium ion battery, so as to improve the long-term storage performance and reliability of the electrochemical device. *Id.* 2:31-44, 2:8-16, 27:41-61.

49. While the '363 Patent contemplates that the addition of film-forming additives such as VC, VEC, FEC, PS and DTD can further improve the stability of the solid electrolytic interface, it only tests between one and three such additives in isolation for examining the voltage drop in storage. *Id.* 30:47-31:7.

V. LEVEL OF ORDINARY SKILL IN THE ART

50. Each of the arguments below should be considered from the standpoint of a POSA in the field of the '363 Patent.

51. I understand that Petitioner provides the following definition of a POSA:

Petitioner submits that a person of ordinary skill in the art for the field of the '363 patent would have 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. It is consistent

with the field provided by the '363 patent: "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, 1:13-15. Ex. 1003, ¶¶24-25.

Pet. at 12.

52. For purposes of this declaration in support of Patent Owner's Preliminary Response, I offer no independent opinion of the level of ordinary skill in the art but have adopted the definition proposed by Petitioner. I reserve the right to further address the level of ordinary skill in the art if this proceeding is instituted.

VI. THE BOARD SHOULD NOT INSTITUTE INTER PARTES REVIEW

53. I understand that in order for an *inter partes* review to be instituted, the Petition must establish that there is a reasonable likelihood that at least one challenged claim is unpatentable. For at least the reasons I explain below, it is my opinion that the Petition fails to do so.

A. Ground 1: Hong Does Not Anticipate Claims 1-6, 11, 13, and 16

Petitioner contends that Hong anticipates claims 1-6, 11, 13, and 16 of the '363 Patent. These claims recite:

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

about $0.1 \leq (X/Y) \leq \text{about } 8$ (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):

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

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

CN—R1—CN (4);

$\text{CN—R2—(O—R3)}_n\text{—O—R4—CN}$ (5);

or a combination thereof,

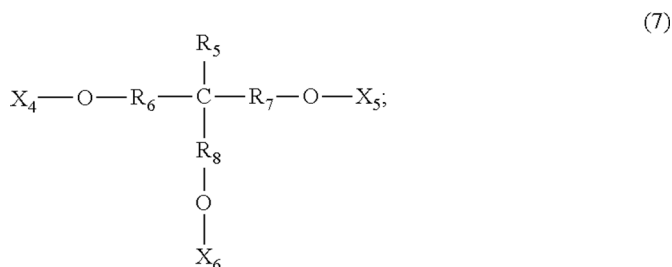
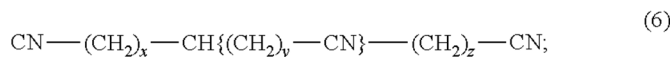
where R1, R2, R3 and R4 are each independently an alkylene group having 1-5 carbon atoms or an alkenylene group having 2-5 carbon atoms,

and n represents an integer from 0 to 5.

3. The electrolyte according to claim 1, wherein the dinitrile compound is one selected from the group consisting of butanedinitrile, glutaronitrile, adiponitrile, 1,5-dicyanopentane, 1,6-dicyanohexane, 1,7-dicyanoheptane, 1,8-dicyanooctane, 1,9-dicyanononane, 1,10-dicyanodecane, 1,12-dicyanododecane, tetramethylbutanedinitrile, 2-methylglutaronitrile, 2,4-dimethylglutaronitrile, 2,2,4,4-tetramethylglutaronitrile, 1,4-dicyanopentane, 2,6-dicyanoheptane, 2,7-dicyanooctane, 2,8-dicyanononane, 1,6-dicyanodecane,

1,2-dicyanobenzene, 1,3-dicyanobenzene, 1,4-dicyanobenzene, 3,5-dioxa-pimelonitrile, 1,4-bis(cyanoethoxy)butane, ethylene glycol bis(2-cyanoethyl)ether, diethylene glycol bis(2-cyanoethyl)ether, triethylene glycol bis(2-cyanoethyl)ether, tetraethylene glycol bis(2-cyanoethyl)ether, 3,6,9,12,15,18-hexaoxaicosanoic dinitrile, 1,3-bis(2-cyanoethoxy)propane, 1,4-bis(2-cyanoethoxy)butane, 1,5-bis(2-cyanoethoxy)pentane, ethylene glycol bis(4-cyanobutyl)ether, 1,4-dicyano-2-butene, 1,4-dicyano-2-methyl-2-butene, 1,4-dicyano-2-ethyl-2-butene, 1,4-dicyano-2,3-dimethyl-2-butene, 1,4-dicyano-2,3-diethyl-2-butene, 1,6-dicyano-3-hexene, 1,6-dicyano-2-methyl-3-hexene, 1,6-dicyano-2-methyl-5-methyl-3-hexene, and any combination thereof.

4. 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.

5. The electrolyte according to claim 1, wherein the trinitrile compound is one selected from the group consisting of: 1,3,5-pentanetricarbonitrile; 1,2,3-propanetrinitrile; 1,3,6-hexanetricarbonitrile; 1,2,6-hexanetricarbonitrile; 1,2,3-tris(2-cyanoethoxy)propane; 1,2,4-tris(2-cyanoethoxy)butane; 1,1,1-tris(cyanoethoxymethylene)ethane; 1,1,1-tris(cyanoethoxymethylene)propane; 3-methyl-1,3,5-tris(cyanoethoxy)pentane; 1,2,7-tris(cyanoethoxy)heptane; 1,2,6-tris(cyanoethoxy)hexane; 1,2,5-tris(cyanoethoxy)pentane; and any combination thereof.

6. The electrolyte according to claim 1, wherein X is about 0.01-10 wt %, Y is about 0.01-10 wt %, and a weight percentage Z of the propyl propionate is about 5-50 wt %.

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.

13. 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):

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

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

16. 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):

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

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

1. Petitioner Fails to Show that Hong Anticipates the Claimed Formula (3) Range of Claim 1

54. I understand that Petitioner points to the electrolyte compositions disclosed for Embodiments 2, 18 and 25, and Comparison Case 6 (the Hong “Examples”), in Table 3 of Hong, and alleges that these electrolyte compositions anticipate the claimed Formula (3) range. *See* Pet. at 19. I disagree at least because the disclosure of Hong does not provide sufficient detail that would allow the POSA to determine that Hong discloses the Formula (3) range. Indeed, as evidenced by the assumptions made by Dr. Anderman, unsupported and incorrect as they are, the POSA would have to make numerous assumptions that are not disclosed by Hong to even be able to calculate the inputs to Formula (3).

55. Hong is directed to the use of rare tricyanophosphite and tricyanophosphate “functional compounds” in electrolyte solutions to provide

certain performance advantages for the lithium-ion battery. Ex. 1005, 1 (Abstract), ¶¶5-9, 17-18, 20-24, 39-43. Indeed, Hong discloses fourteen functional compounds included in twenty-five electrolyte solution embodiments mixed with numerous other components. *Id.* ¶¶20-24, 33-35. Hong conducts performance testing on lithium-ion batteries made with these electrolyte solutions to test the effect that the tricyanophosphite and tricyanophosphate functional compounds have on performance of the batteries. *Id.* ¶¶39-43. Hong never discloses “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): $0.01 \leq (Y/Z) \leq \text{about } 0.3$ (3).” Ex. 1005, Claim 1.

56. Unlike Hong’s Examples, which constitute electrolyte solutions including an average of 12-14 components focused on the effect that its rare tricyanophosphite and tricyanophosphate functional compounds have on lithium-ion battery performance, the ’363 Patent’s invention is directed to three components² – a dinitrile compound, a trinitrile compound, and propyl propionate

² As discussed in Section IV.B, while the ’363 Patent contemplates that the addition of film-forming additives such as VC, VEC, FEC, PS and DTD can further improve the stability of the solid electrolytic interface, it only tests between

– mixed in specific wt % ratio ranges (as claimed in Formulas (1)-(3)) that were unexpectedly found to result in a firm, protective SEI film on the surface of the cathode that was not easily decomposed, and which could provide performance improvements at a high potential of 4.45 V and effectively reduce DC internal resistance of the battery. Ex. 1001 at 1:49-56 (“The present inventors unexpectedly found that by using a mixture of a dinitrile compound, a trinitrile compound and propyl propionate, a firm protective film which is not easily decomposed on the surface of the cathode at a high potential can be formed. The electrolyte according to the embodiment of the present application can effectively inhibit the increase in DC internal resistance of the electrochemical device”); *Id.* 27:55-61 (“The ratio of the content of the trinitrile compound to the content of propyl propionate has great effect on the change in DC internal resistance of the battery. When Y/Z is within the range of 0.01-0.3, a better inhibition effect on the increase in DC internal resistance is achieved.”). Hong makes no mention that its electrolyte solutions can provide its alleged advantages at a high potential.

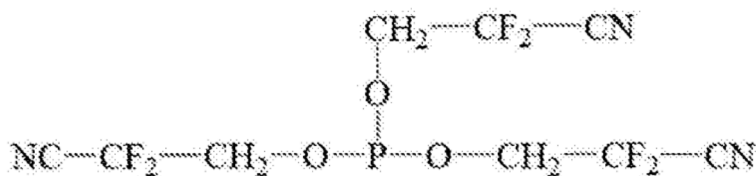
one and three such additives in isolation for examining the voltage drop in storage. The ’363 Patent does not contemplate using test electrolyte solutions having as many as 14 solvents, additives, functional compounds, and electrolyte substances, as Hong does.

57. Indeed, I understand that during prosecution of the application that became the '363 Patent, I understand that the Applicant asserted that claimed Formula 3 resulted in unexpected results. Specifically, Applicant stated: "In the structure and operation of the present invention as claimed, it was found that when Y/Z is within the range of 0.01-0.3, the electrolyte has a better inhibit effect on the increase in the DC internal resistance." Ex. 1002, 861. Hong says nothing about this critical formula and/or reducing DC internal resistance of the battery.

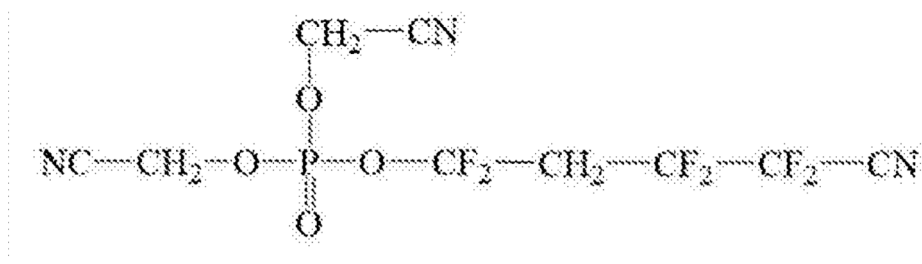
58. Instead of identifying the formula or a disclosure related to the critical nature of the ratio of the content of the trinitrile compound to the content of propyl propionate, Petitioner relies on Hong's Embodiments 2, 18 and 25, and Comparison Case 6. Pet. at 14-21. The Hong Examples, however, are very different from those claimed in the '363 Patent, and each comprise numerous additional components, including organic solvents, solid and liquid "additives," "functional compounds," and electrolyte substances. Specifically, Hong discloses that each of these electrolyte solutions includes:

- A mixture of four organic solvents comprising ethylene carbonate (EC), propyl propionate (PP), diethyl carbonate (DEC), and propylene carbonate (PC). Ex. 1005, ¶¶12-13, 26, 33-35. For these organic solvents, Hong provides a relative mass ratio of each organic solvent based on the total mass of the organic solvents. *Id.*

- Between six and seven “[a]dditives,” including 1,3-propane sultone (PS), fluoroethylene carbonate (FEC), vinyl ethylene carbonate (VEC), and ethylene sulfate (DTD), as well as the dinitriles adiponitrile (ADN), succinonitrile (SN), and ethylene glycol bis(propionitrile) ether (DENE). For Embodiment 25 and Comparison Case 6, Hong also includes the trinitrile 1,3,6-hexanetricarbonitrile (HTCN) as an “additive.” *Id.* ¶¶15, 33-35, 38. For each of these additives, Hong provides a mass percentage (“mass %”) concentration based on a total mass of the electrolyte solution. *Id.*
- A “[f]unctional compound” (for Embodiments 2, 18 and 25), constituting the trinitrile Compound I₁ for Embodiments 2 and 28, or the trinitrile Compound II₆ for Embodiment 25. *Id.* ¶¶20-24, 33-35, 38. For each of these functional compounds, Hong provides a mass % concentration based on a total mass of the electrolyte solution. *Id.* Below are the chemical structures of Hong’s trinitrile compounds I₁ and II₆.



Compound I₁



Compound II₆

Id. ¶¶20-24.

- An “[e]lectrolyte substance” comprising either LiPF₆ (for Embodiments 2 and 18) or LiPF₆ + LiTFSI (for Embodiment 25 and Comparison Case 6). *Id.* ¶¶11-12, 33-35, 38. For each of these electrolyte substances, Hong provides a molarity (M) concentration, which is equivalent to the number of moles of the electrolyte substance divided by the total volume of the electrolyte solution. *Id.*

59. Table 1 below, excerpted from Hong’s Table 3, presents the components and concentrations of the various electrolyte components that Hong discloses for Embodiments 2, 18, and 25, and Comparison Case 6, where the various dinitrile compounds are highlighted in blue, the various trinitrile compounds are highlighted in green, and the propyl propionate component is highlighted in red. I added annotations to this table in the form of concentration units for each component highlighted in purple.

	<u>Organic solvent (mass ratio)</u>	<u>Additive (mass % in final electrolyte)</u>	<u>Functional compound (mass % in final electrolyte)</u>	<u>Electrolyte substance (molarity concentration in final electrolyte)</u>
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% 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 1. Hong’s Embodiments 2, 18, and 25, and Comparison Case 6.

60. Hong does not expressly disclose, in Table 1 above or anywhere else, a *weight percentage* (“wt %”) of propyl propionate *based on a total weight of the electrolyte solution* as claimed, but rather, discloses a relative *mass ratio* of each organic solvent based on the total mass of the organic solvents. Ex. 1003, ¶108. Petitioner’s expert Dr. Anderman acknowledges that Hong discloses “organic solvents [that are] mixed according to a *mass ratio*,” and that “[f]or Embodiments 2, 18, 25, and Comparison Case 6, *the base organic solvent [(i.e., not the total electrolyte solution)]* is 25 wt % propyl propionate (PP), 25 wt % ethylene carbonate (EC), 40 wt % diethyl carbonate (DEC), and 10 wt % propylene

carbonate (PC).” *Id.* (emphasis added). In fact, every single embodiment of Hong in Hong’s Table 3 that includes propyl propionate provides PP at an unvarying mass ratio of 25 %, indicating that Hong never appreciates or tests the impact of varying the amount PP. Ex. 1005, ¶¶33-35.

61. Despite Hong’s Examples comprising between 12-14 components having three different types of concentration units – mass ratio of the organic solvents, mass % based on the final electrolyte mass, and molarity (M) – which are respectively based on different measurements (total mass of the organic solvents, total mass of the electrolyte solution, and total volume of the electrolyte solution), Hong does not provide such measurements (i.e., the total mass, total weight, or total volume of each final electrolyte solution), which would be necessary to even attempt to calculate a theoretical wt % of the propyl propionate component based on the total weight of the electrolyte solution.

62. It is my opinion that, without any disclosure related to the critical nature of the ratio of the content of the trinitrile compound to the content of propyl propionate and without any mention of the total mass, total weight, or total volume of each final electrolyte solution, which Hong does not provide, it is improper for Dr. Anderman or anyone to conclude that she/he can determine that Hong discloses the claimed wt %.

63. Nor does Hong disclose any chemical or physical properties of its functional compounds I₁ and II₆. For example, Hong does not disclose the density of these compounds at room temperature, which would be necessary to try to calculate the mass, weight, and volume contributions of these compounds for each final electrolyte solution, which in turn would be necessary to accurately calculate a theoretical propyl propionate wt % value in accordance with Dr. Anderman's assumptions and calculations. Rather, all that Hong provides for these compounds is their chemical structures. Ex. 1005, ¶¶20-24.

a. Dr. Anderman's Assumptions Are Unjustified

64. Because Hong does not disclose any wt % values of propyl propionate, and discloses three different concentration units for its various components that are based on three different measurements – total mass of the organic solvents, total mass of the electrolyte solution, and total volume of electrolyte solution – without actually providing those measurements, it is my opinion that Dr. Anderman cannot directly and accurately calculate a theoretical wt % of propyl propionate. Instead, Petitioner and Dr. Anderman must rely on various unjustified and scientifically unsound assumptions regarding the total volume of the electrolyte solution, including how the various liquid and solid components of

Hong's electrolyte solutions would interact with each other at room temperature³ to affect such volume despite the unpredictability of combining those liquid and solid components, and regarding the physical properties of Hong's functional compounds I₁ and II₆, in an attempt to calculate theoretical propyl propionate wt % values that allegedly would have met the claimed Formula (3) range. Specifically, the Petition states:

Petitioner's Expert, Dr. Anderman, used Hong's description of the electrolyte preparation method and proportions of each component to determine the propyl propionate weight percentage (Z) in Embodiments 2, 18, 25, and CC6. Dr. Anderman's calculations incorporate three assumptions: (1) the total volume of the liquid components does not meaningfully change after mixing, (2) the solid components do not meaningfully contribute to the total volume of the electrolyte, and (3) Hong's tricyanophosphate and tricyanophosphite compounds are liquids at room temperature with a density of 0.60 g/cm. These assumptions are justified by Dr. Anderman's experience, the similarity of the solvent components, the

³ Dr. Anderman indicates that his calculations assume that Hong's electrolyte solutions are prepared at room temperature. See Ex. 1003, ¶¶109, 111, 112-114, 132, 149.

common effect of solutes on solvent organization, and the known densities of common organic compounds.

Pet. at 19-20.

65. However, it is my opinion that, Dr. Anderman's assumptions are unjustified and cannot be applied to calculating accurate component wt % values given the complexity of Hong's electrolyte formulations and the lack of disclosure in Hong regarding the preparation of such formulations. For example, when a large number of electrolyte components such as those of Hong, including Hong's various additives, organic solvents, rare functional compounds, and electrolyte substances, are mixed, the behavior and interactions of such components, and the effect that mixing these components have on the final volume of the final electrolyte solution, are extremely difficult, if not impossible to accurately predict let alone calculate.

66. As explained *supra* ¶¶55-56, Hong is directed to the use of rare tricyanophosphate and tricyanophosphite functional compounds, along with numerous other additives, solvents, and electrolyte substances, for improved battery performance, whereas the '363 Patent is directed to the use of a dinitrile, a trinitrile, and propyl propionate in specific wt % ratio ranges that allow a battery to perform well at high potentials.

67. Hong does not expressly disclose any wt % ratios between dinitrile and trinitrile compounds as claimed, or between any trinitrile compounds and propyl propionate as claimed, and does not expressly disclose any ranges of any such wt % ratios as claimed. Hong discloses, with respect to the four Examples that Petitioner points to, electrolyte solutions having 12-14 components, each including a functional compound whose physical properties and chemical properties are unknown, with different concentration units for the various components based on different measurements (total mass of the organic solvents, total mass of the electrolyte solution, and total volume of the electrolyte solution), none of which are specified by Hong. Without additional information, a POSA reading Hong would not have been able to accurately derive propyl propionate wt % values that meet the claimed Formula (3) range.

68. In addition, as described below, each of Dr. Anderman's assumptions are also improper because they include various unjustified or scientifically unsound assumptions that a POSA skilled in the art of lithium-ion battery electrolyte preparation would not make.

(i) **Dr. Anderman's First Assumption is Unjustified and Unscientific**

69. Dr. Anderman's first assumption is that: "(1) the total volume of the liquid components does not meaningfully change after mixing." Ex. 1003, ¶110.

Dr. Anderman notes that “this assumption is justified based on the similarity of the liquid components in Embodiments 2, 18, 25, and Comparison Case 6” and that “[f]or 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.” *Id.* Dr. Anderman then identifies PP, DEC, PC, ADN, VEC, DENE, FEC, and HTCEN as liquid components in Hong’s examples, and notes that “[e]thylene carbonate (EC) has long been known to function as a solvent when mixed with liquids,” suggesting that he is also considering EC to be a liquid component for purposes of making his first assumption. *Id.* ¶111.

70. It is my opinion that Dr. Anderman’s first assumption is flawed for numerous reasons.

71. As an initial matter, Dr. Anderman does not explain what he means by “meaningfully” when he states that “the total volume of the liquid components does not *meaningfully* change after mixing,” implicitly conceding that he considers some level volume change to be acceptable to his analysis. Ex. 1003, ¶110. For example, Dr. Anderman does not provide any volume change percentage threshold (e.g., 1%, 5%, 10%) that he considers to be meaningful. Without any concrete indication of what is meant by “meaningful[],” it is impossible to understand the metes and bounds of Dr. Anderman’s first assumption and to assess how the changes in the total volume would impact the calculations in formula (3).

72. In addition, it is not clear how many of Hong's components must be considered liquids *before mixing* as contemplated by Dr. Anderman's first assumption. For example, Dr. Anderman appears to erroneously include EC in his list of components that he considers liquid components for his first assumption, but the Material Safety Data Sheet ("MSDS") for ethylene carbonate (EC) that Dr. Anderman cites (Ex. 1014) indicates that EC is in a solid crystalline form, not in liquid form, at room temperature. Ex. 1003, ¶111. Dr. Anderman appears to consider EC to be a liquid component because "[e]thylene carbonate (EC) has long been known to function as a solvent *when mixed* with liquids," but Dr. Anderman's first assumption is that "the total volume of the *liquid components [before mixing]* does not meaningfully change *after mixing*," not that the volume of a solid component before mixing does not meaningfully change after mixing. Ex. 1003, ¶110-111. In fact, it is known that the volumes of solid components may materially change when dissolved in a solvent. Thus, whether EC functions as a solvent or liquid *after* mixing with liquids would be irrelevant to Dr. Anderman's first assumption, and EC cannot be considered a liquid component in Dr. Anderman's first assumption because it is a solid at room temperature.

73. Dr. Anderman also assumes that FEC is also a liquid at room temperature, whereas the MSDS for FEC that Dr. Anderman cites indicates that FEC's state of matter is "[w]ax like" at room temperature. Ex. 1003, ¶111; Ex.

1015, 5. Furthermore, Dr. Anderman assumes that Hong's electrolyte solutions are prepared at room temperature, but a POSA would have understood "room temperature" to not have one universally agreed and defined temperature, but to possibly constitute any temperature between 18 °C and 25 °C depending on the source defining such "room temperature." And the MSDS for FEC that Dr. Anderman cites indicates that FEC's melting point is 18 – 23 °C, which creates ambiguity as to whether FEC is a solid or liquid at room temperature. Ex. 1015, 5. Because Dr. Anderman has put the states of matter of Hong's components at issue for his first assumption, the states of matter of each of Hong's components are critical, but a POSA would not have been able to know the state of matter of FEC at room temperature.

74. In addition, Hong's Examples also include functional compounds I₁ and II₆ – whose physical and chemical properties, including their states of matter at room temperature, are not provided by Hong, and are not described in any published literature, including any literature cited by Dr. Anderman. Therefore, it is not possible to know if these compounds are to be treated as liquid components for Dr. Anderman's first assumption. Notably, Dr. Anderman takes conflicting positions as to whether these compounds are liquids or not. In his third assumption, Dr. Anderman assumes that Compounds I₁ and II₆ are liquids at room temperature, yet in his first assumption, he does not include these compounds in

his list of liquid components. Ex. 1003, ¶¶111, 114. Again, because Dr. Anderman has put the states of matter of Hong's components at issue for his first assumption, the states of matter of each of Hong's components are critical to his first assumption, yet as with FEC, a POSA would not have been able to know the states of matter of Compounds I₁ and II₆.

75. Generally, although I believe that Dr. Anderman's first assumption may possibly be a reasonable one to make when mixing a small number of well-understood liquids with similar documented chemical and physical properties, with predictable and known behaviors, and that do not react with each other or change forms when mixed, that is not the case with Hong's Examples. Hong's Examples contain between 6-8 different liquid components (assuming EC is a solid component before mixing, which Dr. Anderman has not done, and also depending on whether FEC and Compounds I₁ and II₆ are considered liquid components or not) that each have widely varying physical and chemical properties as shown in Table 2 below, which presents data for Hong's components from the MSDS references that Dr. Anderman cites.

	Component	Molecular Weight	State of Matter at RT	Density	MP	BP	Flash Point	Vapor Pressure	Water Solubility
Organic Solvent	ethylene carbonate (EC)	88.06 g/mol	solid (crystalline)	1.321 g/cm ³ at 25 °C	35-38 °C	243-244 °C	143 °C	1 hpA at 20 °C	778 g/l at 20 °C
	propyl propionate (PP)	116.16 g/mol	liquid	0.881 g/cm ³ at 25 °C	- 76 °C	122-124 °C	19 °C	1.7 hPa at 20 °C	0.2 g/l at 20 °C
	diethyl carbonate (DEC)	118.13 g/mol	liquid	0.975 g/cm ³ at 25 °C	- 43 °C	126-128 °C	25 °C	13 hPa at 23.8 °C	18.8 g/l at 20 °C
	propylene carbonate (PC)	102.09 g/mol	liquid	1.2047 g/cm ³ at 20 °C	- 55 °C	240 °C	132 °C	0.17 hPa at 20 °C	175 g/l at 25 °C
Additive	1,3-propane sultone (PS)	122.14 g/mol	solid	1.39 g/mL (g/cm ³) at 25 °C	30 - 33 °C	180 °C at 40 hPa	171.5 °C	0.003 hPa at 20 °C	100 g/l
	fluoroethylene carbonate (FEC)	106.05 g/mol	"Wax like"	"1,485 g/cm ³ "	18-23 °C	212 °C	> 102.2 °C	N/A	N/A
	adiponitrile (ADN)	108.14 g/mol	liquid	"0.961 g/cm ³ "	0-1 °C	161-162 °C at 15 hPa; 295 °C at 1013 hPa	> 110 °C	N/A	N/A
	vinyl ethylene carbonate (VEC)	114.10 g/mol	liquid	1.188 g/cm ³ at 25 °C	< -30 °C	237 °C	96.9 °C	0.0458 hPa at 25 °C	66.44 g/l at 20 °C
	ethylene glycol bis(propionitrile) ether (DENE)	168.2	liquid	"1.07"	N/A	165 °C	N/A	N/A	N/A
	1,3,6-hexanetricarbonitrile (HTCN)	161.2 g/mol	liquid	1.04 g/cm ³ at 25 °C	N/A	255-260 °C	85 C	N/A	N/A
Functional Compound	I1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	II6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 2. Physical and Chemical Properties of Select Hong Components According to Dr. Anderman's MSDS References.⁴

76. In addition to the issues above, Dr. Anderman also does not explain what he means by “similarity” when he states that his “[first] assumption is justified based on the *similarity of the liquid components*.” Ex. 1003, ¶110. Dr. Anderman notes that, “[f]or example... the polarity of the liquid components is similar,” but does not explain if polarity is the only factor by which to determine similarity, or if other properties, such as density, solubility, melting point, and

⁴ See Exs. 1014, 1020, 1011, 1019, 115, 1010, 1024, 1012 and 1016.

boiling point, must also be considered. *Id.* Further, Dr. Anderman does not provide any objective standard by which he purports to determine *when* any particular properties of two liquids might be similar enough to support his first assumption. Considering polarity as an example, Dr. Anderman does not tell us how close the polarities of two liquids would need to be to justify his first assumption.

77. In fact, contrary to Dr. Anderman's opinion, the liquid components disclosed in Hong's Examples do not have similar polarities. The polarity of a solvent is directly related to its dielectric constant ϵ , such that the dielectric constant ϵ of a solvent is a measure of its polarity. The higher the dielectric constant of a solvent, the more polar it is. However, Hong's organic solvents, for example, have widely varying dielectric constants as shown in Table 3 below.

Organic Solvent	Temperature (°C)	Dielectric Constant ϵ
EC	25	95.3 ⁵
DEC	20	2.82 ⁶
PC	20	64.9 ⁷
PP	20	4.7 ⁸

Table 3. Dielectric Constants of Hong's Organic Solvents.

78. As shown above, assuming that EC is a liquid component as Dr. Anderman assumes, there is a 34-fold difference in polarity between EC and DEC, and a 20-fold difference in polarity between EC and PP. In addition, there is a 23-fold difference in polarity between PC and DEC, and a 14-fold difference in polarity between PC and PP. Therefore, it is my opinion that Dr. Anderman's assumption that all of Hong's liquid components have similar polarities, which appears to be the only basis for his opinion that the liquid components are "similar," which in turn appears to be the basis for his first assumption, is necessarily incorrect.

⁵ See Ex. 1025, Table 2.

⁶ See Ex. 2004, 13.

⁷ See Ex. 2005, 1.

⁸ See Ex. 2004, 34.

79. Furthermore, Dr. Anderman does not actually provide or point to any physical, chemical, or other properties of Hong's liquid components to support his opinion that they are "similar" enough to justify his first assumption. All he provides are conclusory statements that his "[first] assumption is justified based on the *similarity of the liquid components*," and that, "[f]or example... the polarity of the liquid components is similar," without presenting or pointing to any polarity values of the liquid components to allow assessment of whether those polarity values are, in fact, similar. Ex. 1003, ¶110. Contrary to Dr. Anderman's conclusions, Table 2 above indicates that Hong's liquid components have widely varying physical properties, and Table 3 shows that Hong's organic solvents have widely varying dielectric constant (i.e., polarity) values, undermining Dr. Anderman's statement that his "[first] assumption is justified based on the *similarity of the liquid components*." *Id.*

80. For the above reasons, it is my opinion that Dr. Anderman's first assumption is unjustified, and thus Dr. Anderman's calculations based on his first assumption are flawed.

(ii) Dr. Anderman's Second Assumption is Unjustified

81. Dr. Anderman's second assumption is that "the solid components ("solutes") do not meaningfully contribute to the total volume of the electrolyte."

Ex. 1003, ¶112. Dr. Anderman attempts to justify his second assumption by explaining that “[w]hen 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... 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.” *Id.*

82. As an initial matter, and as with his first assumption, Dr. Anderman does not explain what he means by “meaningfully” when he states that “the solid components (“solutes”) do not *meaningfully* contribute to the total volume of the electrolyte.” *Id.* For example, Dr. Anderman does not provide any volume contribution by the solid components that could be considered meaningful. Without any concrete indication of what is meant by “meaningful[],” it is difficult to understand the metes and bounds of Dr. Anderman’s second assumption and to assess how the solutes’ contribution to the total volume would impact the calculations in Formula (3).

83. And as with Dr. Anderman’s first assumption, where there is uncertainty as to which of Hong’s components should be considered liquid components, here, it is also uncertain which of Hong’s components should be considered solid components. For example, as discussed above, EC is in a solid crystalline form at room temperature, yet Dr. Anderman considers EC a liquid for

his first and second assumptions because “[e]thylene carbonate (EC) has long been known to function as a solvent *when mixed* with liquids.” Ex. 1003, ¶111. Yet Dr. Anderman’s second assumption that “the solid components (“solutes”) do not meaningfully contribute to the total volume of the electrolyte” contemplates that it is the components that are solid *before mixing* that do not meaningfully contribute to the total volume of the electrolyte *after mixing*. As such, EC should be considered a solid component for Dr. Anderman’s second assumption, but Dr. Anderman treats it as a liquid component for both his first and second assumptions, undermining both assumptions. *Id.* ¶¶111-112, 116, 121, 123, 125, 127.

84. In addition, as explained above and according to the MSDS reference for FEC, FEC has a “[w]ax like” state of matter at room temperature, and a melting point of 18 – 23 °C, which creates ambiguity as to whether FEC is a solid or liquid at “room temperature,” which neither Dr. Anderman nor Hong defines. *See* Ex. 1003, ¶¶109, 111, 112-114, 132, 149. Because Dr. Anderman has put the states of matter of Hong’s components at issue for his second assumption, the states of matter of each of Hong’s components are critical, but a POSA would not have been able to know if FEC is a solid or liquid at room temperature for Dr. Anderman’s second assumption.

85. In addition, as described above, the physical and chemical properties for Hong’s functional compounds I₁ and II₆, including their states of matter at room

temperature, are not provided by Hong, and are not described in any published literature, including any literature cited by Dr. Anderman. Therefore, it is not possible to know if these compounds are to be treated as solid components with respect to Dr. Anderman's second assumption. As discussed *supra* ¶74, Dr. Anderman takes conflicting positions as to whether these compounds are liquids or not – in his third assumption, Dr. Anderman assumes that compounds I₁ and II₆ are liquids at room temperature, yet in his first assumption, he does not include these compounds in his list of liquid components, further undermining both his first and second assumptions. Ex. 1003, ¶¶110-114. Again, because Dr. Anderman has put the states of matter of Hong's components at issue for his second assumption, the states of matter of each of Hong's components is critical, but a POSA would not have been able to know if Compounds I₁ and II₆ are solids or liquids at room temperature for Dr. Anderman's second assumption.

86. Contrary to Dr. Anderman's second assumption, it is my opinion that a solid dissolved in a liquid does in fact take up solution volume, and thus does contribute to the total volume of the solution. While Dr. Anderman's second assumption may possibly be a reasonable one to make when dealing with very dilute solutions (e.g., less than 0.1 M) comprising a small number of solutes and solvents with well-known properties and reactivities, that is not the case with Hong's Examples. Rather, Hong's electrolyte solutions contain 12-14 different

components, including 4-8 solid components mixed with 6-8 liquid components (assuming that EC is a solid component before mixing, which Dr. Anderman has not done, and also depending on whether FEC and Compounds I₁ and II₆ are solid components or not), including the rare functional compounds I₁ and II₆ whose chemical and physical properties are unknown, as well as electrolyte substances in concentrations of 1.1 M LiPF₆ or 1.0 M LiPF₆ + 0.5 M LiTFSI. It is my opinion that when there are so many different solid and liquid components in an electrolyte solution with unknown reactivities to each other, it is impossible to accurately predict, using generalized assumptions and calculations, how these different components will actually interact with each other, and the degree to which the total volume of the electrolyte solution, will be affected by the solid components.

87. In fact, Hong's electrolyte solutions are too complex and not dilute enough for Dr. Anderman's second assumption to apply. For example, the added concentrations in Hong's Examples of even just the PS, SN and DTD additives that Dr. Anderman considers to be solid components, are 4-4.5 mass %. The actual concentration of all of the solid components in Hong's Examples would be significantly higher, if the concentrations of the electrolyte substance LiPF₆ and LiTFSI (which are solid powders at room temperature), FEC (which is "[w]ax like" and could be considered a solid at room temperature), EC (which is crystalline at room temperature), and functional compounds I₁ and II₆ (for which

no properties are known but which could possibly be solids at room temperature), are properly accounted for.

88. Thus, to suggest, as Dr. Anderman does, that when Hong's 4-8 solid solutes are mixed with Hong's 6-8 liquid solvents, the solvent molecules would move closer together around the solutes, yet that the solutes would not "meaningfully" contribute to the total volume of the electrolyte solution, is, in my opinion, both incorrect and contradictory. For example, when a solid solute such as the LiPF_6 electrolyte substance in Hong is added to a solvent or mixture of solvents, it must necessarily take up space when dissolved (solvated) because the Li cation and PF_6 anion that LiPF_6 dissociates into are not point charges that lack intrinsic volume, but rather, take up space in the solution, and thus will be expected to increase the overall volume of the electrolyte solution. For example, the PF_6 anion possesses a volume of $94 \text{ \AA}^3$ and thus each PF_6 anion will be expected to contribute at least $94 \text{ \AA}^3$ in additional volume to the total electrolyte solution, before accounting for any solute-solvent interactions. Ex. 2006 at 15 (Table 6). Further, the larger TFSI anion that is dissociated when LiTFSI is dissolved in a solution possesses a volume of $179 \text{ \AA}^3$ thus contributing additional volume to the electrolyte solution in Hong's Embodiment 25 and Comparison Case 6. *Id.* In comparison, the liquid solvent PC possesses a molecular volume of $141 \text{ \AA}^3$ which places it between that of the PF_6 anion and that of the TFSI anion. Ex. 2007 at 4.

And Dr. Anderman acknowledges that the total volume of the electrolyte will be affected but makes no attempt to quantify or measure the degree of that effect. Ex. 1003, ¶¶110-112.

89. For the above reasons, it is my opinion that Dr. Anderman's second assumption is unjustified and scientifically unsound.

**(iii) Dr. Anderman's Third Assumption is
Unjustified and Unscientific**

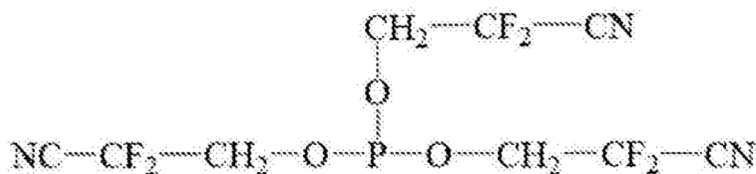
90. Dr. Anderman's third assumption is that "(3) Hong's tricyanophosphate and tricyanophosphite compounds are liquids at room temperature with a density of 0.60 g/cm³." Ex. 1003 ¶114. Dr. Anderman's purported justification for this assumption is that:

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.

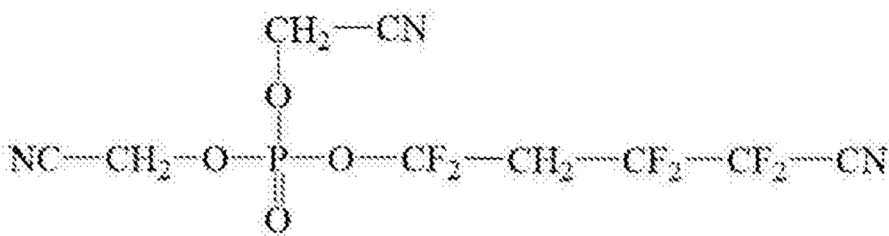
Id.

91. And because Hong's tricyanophosphate and tricyanophosphite compounds include Compound I₁ and Compound II₆ present in the Examples at issue, Dr. Anderman's third assumption necessarily assumes that Compound I₁ and Compound II₆ are liquids at room temperature and have a density of 0.60 g/cm³. Ex. 1003, ¶¶20-24.

92. As explained above, neither Hong nor Dr. Anderman provide any physical, chemical, or other properties of Compound I₁ and Compound II₆, apart from the following chemical structures provided in Hong:



Compound I₁



Compound II₆

Id.

93. To my understanding, Compounds I₁ and II₆ are not common or well-known organic compounds in the field of lithium-ion battery electrolytes, let alone in the general field of organic chemistry. In fact, I am not aware that there is now, or that there was when the '363 Patent was filed, any information on any chemical or physical properties of these compounds available in any published scientific literature. I understand that neither Petitioner nor Dr. Anderman cite to any scientific literature indicating or suggesting that these compounds are liquids at room temperature. It is therefore my opinion that Dr. Anderman does not provide any rational support for his assumption that these compounds are liquids at room temperature.

94. It is also my opinion that Dr. Anderman's reliance on the densities of the compounds in the table of arbitrary "common organic compounds" (Exhibit 1027) that he cites is insufficient justification for his assumption that Compounds I₁ and II₆ have a density of 0.60 g/cm³. Ex. 1003, ¶114; Ex. 1027. Not only do the compounds in Exhibit 1027 list only "common" organic compounds without capturing the essentially infinite number of organic compounds that exist, but Dr. Anderman does not provide any convincing reason why the densities of Compounds I₁ and II₆ should be determined based on the lowest density listed in his short list of common organic compounds. *Id.*

95. For the above reasons, it is my opinion that Dr. Anderman's third assumption is flawed, and Dr. Anderman's calculations based on his third assumption are also flawed.

b. Dr. Anderman's Calculations are Also Flawed

96. Even assuming that Petitioner's assumptions are justified, Petitioner's anticipation arguments still fail because Petitioner's calculations, which rely on these assumptions, are themselves rife with inconsistencies and unexplained estimations.

97. Table 5 from Dr. Anderman's declaration (reproduced below), shows the room temperature states of matter, densities, and volume and weight contributions of the various components of Hong's Embodiment 2, as determined by Dr. Anderman based on the MSDSs that he cites.

	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

98. Dr. Anderman’s calculations, however, assume incorrect states of matter, and use inconsistent, incorrect, and/or unreliable density values, for certain components of Hong’s electrolyte solutions.

99. For example, according to Dr. Anderman’s Table 5, EC is a liquid at room temperature. Ex. 1003, ¶45 (Table 5). But as Dr. Anderman’s own cited reference indicates, EC is actually a solid, or in “crystalline” state at room temperature. Ex. 1014 at 5. In addition, the density values for the various electrolyte components of Hong that Dr. Anderman uses for his calculations are inconsistent or unreliable, as they are based on density values at different temperatures, density values without any given corresponding temperatures, or

density values with missing units. For example, the densities that Dr. Anderman uses for PC, DTD and LiTFSI are based on a temperature of 20 °C (Exs. 1019, 1013, 1018), whereas those for EC, PP, DEC, PS, SN, VEC, and LiPF₆ are based on a temperature of 25 °C (Exs. 1020, 1011, 1021, 1022, 1024, 1017). In addition, the density used for DENE, is based on a density from the DENE MSDS that does not include any units at all (Ex. 1012), and the densities used for FEC and ADN are based on densities from the FEC and ADN MSDSs that do not include any temperatures on which those densities are based (Exs. 1015, 1010). In addition, as discussed *supra* ¶¶73-74, 85-86, it is not clear what the states of matter of FEC and Compounds I₁ and II₆ are at room temperature. These issues are further complicated by the fact that Dr. Anderman seeks to prepare on paper Hong's electrolyte solutions at "room temperature" without specifying a numerical temperature, and a POSA would understand room temperature to be anywhere from about 18 °C to about 25 °C depending on the source defining "room temperature." Tables 6-8 from Dr. Anderman's declaration and the corresponding calculations performed by Dr. Anderman, suffer from the same or similar deficiencies described above regarding Dr. Anderman's calculations in Table 5.

100. In addition, Dr. Anderman's calculations for Embodiments 2, 18, and 25, and Comparison Case 6, cannot result in the 1.1 M LiPF₆ or 1.0 M LiPF₆ + 0.5 M LiTFSI electrolyte substance concentrations disclosed by Hong for its Examples

because in calculating wt % values for Hong's components, *Dr. Anderman assumes that the lithium salt(s) and all of the additives are included in 100 mL of the solvent mixture.* Ex. 1003, ¶¶ 115-130. This erroneous assumption in turn increases the final electrolyte solution volume to greater than 100 mL, which in turn lowers the molarity concentration of the lithium salt components, resulting in electrolyte substance molarity concentrations that are less than the 1.1 M LiPF₆ or 1.0 M LiPF₆ + 0.5 M LiTFSI concentrations disclosed by Hong. This error in turn renders Dr. Anderman's wt % calculations for each Hong component incorrect and inaccurate.

101. In addition, in conducting the calculations and derivations for his wt % values based on his three assumptions, Dr. Anderman uses an incomprehensible methodology involving an unstated "initial estimate" and repeated calculations based on such estimate. Ex. 1003, ¶¶ 117-119. Dr. Anderman states that he used an "initial estimate of the final electrolyte mass [to] calculate the mass of each additive using the mass percentages provided by Hong," but does not state what that initial estimate was, nor does he explain the reasoning behind using such an initial estimate. Ex. 1003, ¶ 117. The lack of context is underscored, when Dr. Anderman notes that:

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.

Id. ¶119 (emphasis added).

102. In the cited excerpt above, Dr. Anderman essentially states that he took some unstated, unexplained, and thus unknown to the reader “initial estimate,” added the masses of the various components that were obtained based on various unjustified assumptions, and compared this added mass to the initial estimate. If the added mass did not match such “initial estimate,” the process was repeated, until it eventually did. In my opinion, Dr. Anderman’s methodology and calculations here are both incomprehensible and impossible to follow because it is not known what his “initial estimate” is and what it represents. In fact, it appears that Dr. Anderman seeks to adjust his series of calculations to “fit” a predetermined propyl propionate wt % value that he wants to show. Essentially, Dr. Anderman has attempted to describe, using more scientific language than his actual process, that he “guessed” at the sum of the masses and then did not tell us

what the numerical value of the guess was. It is also my opinion that a POSA reading Hong would have no reason to perform the serial calculations based on guesswork that Dr. Anderman performed here, to meet his initial “estimate” (or guess).

c. Even Putting Aside His Three Assumptions, Dr. Anderman’s Calculations Fail

103. Dr. Anderman also states that, even if his three assumptions above are set aside, Hong would still anticipate the claimed Formula (3) range. I disagree.

104. First, in presenting this opinion, Dr. Anderman repeats the same unfounded, unexplained and inconsistent calculations identified *supra* Section VI.A.1.b.

105. For example, Dr. Anderman again assumes the incorrect states of matter, and uses inconsistent, incorrect, and/or unreliable density values for his calculations based on his three assumptions. Ex. 1003, ¶¶130-151. Dr. Anderman also repeats his erroneous calculations that result in electrolyte substance concentrations that are more dilute, and lower, than the 1.1 M LiPF₆ or 1.0 M LiPF₆ + 0.5 M LiTFSI concentrations that Hong requires, which taint Dr. Anderman’s calculations for every other component. *Id.* Lastly, Dr. Anderman again uses an incomprehensible methodology involving an “initial estimate” that is not known nor explained, “calculated values” and “estimated values” that are not

stated, and repeating his calculations “[i]f there was a difference between the estimated values and the calculated values.” *Id.* ¶¶135-137.

106. In addition, Dr. Anderman makes additional assumptions that are scientifically unsound and incomprehensible. For example, Dr. Anderman states that “[i]f 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.” *Id.* ¶131. Dr. Anderman does not explain here if he is referring to just the four organic solvents, or all of the liquid components of the solution. In addition, Dr. Anderman does not explain what is meant by “smaller molecules” and “larger molecules” in the solvent. *Id.* Dr. Anderman also does not identify where such molecules come from (e.g., whether they come from Hong’s organic solvents, solid additives, liquid additives, functional compounds, or electrolyte substances?). Notably, Dr. Anderman does not provide any explanation to support his opinion as to why such smaller molecules would “occup[y] the space between such larger molecules” to reduce the total volume of the solvents. *Id.*

107. Furthermore, Dr. Anderman notes that “my third assumption 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.” *Id.* ¶146. Here, Dr. Anderman not only repeats his unfounded and unsupported assumption regarding the densities of Hong’s tricyanophosphite and tricyanophosphate compounds discussed *supra* Section VI.A.1.a.(iii), but doesn’t explain what he means by “similarity to compounds having a higher density,” nor explains how such a comparison supports his assumption. *Id.*

108. In addition, Dr. Anderman assumes that there would be an upper limit for the weight percentage of propyl propionate of 25 wt % because the mass ratio of propyl propionate among the four organic solvents is 25%. However, there is no reason why the 25% mass ratio of propyl propionate prior to mixing with the 11-13 other components in Hong’s electrolyte solutions, including other liquid and solvent components, should place an upper limit on the resulting wt % of propyl propionate. As explained above, Hong’s examples are complex electrolyte solution mixtures comprising between 12 and 14 organic solvents, additives, functional compounds, and electrolyte substances, including components with unknown physical and chemical properties. *See Supra* Section VI.A.1. Even for the substances for which physical and chemical properties are known, it is impossible to predict how Hong’s 12-14 components will interact with each other when mixed, including whether they will chemically or physically react with each

other, and affect the final total volume and weight of the electrolyte solution, as well as the final wt % of each component.

109. In addition, Dr. Anderman assumes that “[i]f... 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.” Ex. 1003, ¶149. This assumption is analogous to dropping a stone into a known volume of Hong’s solvent mixture, which necessarily increases the volume of the solvent mix, and then measuring the increase in volume. But this is not how lithium salts and solid additives behave in electrolyte solutions – a stone does not dissolve in organic solvents while lithium salts do.

110. Again, these assumptions do not take into account the complex and unpredictable nature of the interactions between the various components of Hong’s electrolyte solutions. For example, these assumptions assume that EC is a liquid at room temperature when it is actually a solid, and assume that the I₁ and II₆ compounds are liquid at room temperature, when these compounds are actually rare organic compounds whose chemical and physical properties, including their states of matter at room temperature, and their densities, are unknown.

111. Accordingly, it is my opinion that that even putting aside Dr. Anderman’s incorrect assumptions (1)-(3), Hong does not anticipate the claimed Formula (3) range.

2. The '363 Patent's Claimed Formula (3) Range is Critical

112. Even if one were to assume that Dr. Anderman's flawed assumptions and calculations are reasonable and justified, and that Hong discloses a range of Y/Z values that fall within or overlap the claimed range of Formula (3), it is my opinion that the '363 Patent clearly establishes that the claimed Formula (3) range is critical to providing the advantages that the '363 Patent's invention provides, whereas Hong does not.

113. Even if one were to adopt Dr. Anderman's unjustified assumptions and erroneous calculations, Hong, as a whole, discloses, at best, electrolyte solutions with trinitrile and propyl propionate concentration ranges that are broader than the claimed Formula (3) range. For example, Hong's claim 2 recites mass percentages of the functional compound (i.e., a trinitrile) in the electrolyte being in the range of 0.05% –10%, which, assuming Dr. Anderman's assumptions and calculations are proper, and applying such range to some of the disclosed embodiments, results in a Y/Z range that is broader than the claimed Formula (3) range.

114. For example, applying the trinitrile range of Hong's claim 2 to Hong's Embodiment 2 using Hong's smallest disclosed trinitrile and Hong's largest disclosed trinitrile, would respectively result in Y/Z values of 0.494 and 0.0099, both of which are outside of the claimed Formula (3) range for Hong's

Embodiment 2, indicating Y/Z point values outside of the claimed Formula (3) range, and/or a broader Formula (3) range than the claimed Formula (3) range.

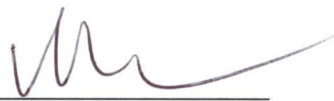
115. On the other hand, the '363 Patent explains that its specific wt % ratio ranges, including Formula (3), were unexpectedly found to provide a firm, protective SEI film on the surface of the cathode that was not easily decomposed, and which could provide performance improvements by allowing a battery to operate at a high potential of 4.45 V and effectively reduce DC internal resistance of the battery. Ex. 1001 at 1:49-56 ("The present inventors unexpectedly found that by using a mixture of a dinitrile compound, a trinitrile compound and propyl propionate, a firm protective film which is not easily decomposed on the surface of the cathode at a high potential can be formed. The electrolyte according to the embodiment of the present application can effectively inhibit the increase in DC internal resistance of the electrochemical device"); *Id.* 27:55-61 ("The ratio of the content of the trinitrile compound to the content of propyl propionate has great effect on the change in DC internal resistance of the battery. When Y/Z is within the range of 0.01-0.3, a better inhibition effect on the increase in DC internal resistance is achieved."). Hong never mentions such criticality of the claimed Formula (3) range, nor the advantages of the '363 Patent that such narrow, specific Formula (3) range provides.

3. Claims 2-12 Are Not Unpatentable

116. Claims 2-12 are not unpatentable for the same reasons as discussed above with respect to claim 1. I reserve the right to address claims 2-12 individually if this proceeding is instituted.

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

Executed on May 30, 2023, in Bellingham, WA.

A handwritten signature in dark ink, consisting of a series of loops and a long horizontal stroke, positioned above a solid horizontal line.

Victor R. Koch