

Declaration of Dean R. Wheeler, Ph.D
IPR2025-00722
U.S. Patent No. 11,799,131

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: IPR2025-00722

U.S. Patent No. 11,799,131

**DECLARATION OF DEAN R. WHEELER, Ph.D., IN SUPPORT
OF PATENT OWNER'S PRELIMINARY RESPONSE**

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I, Dean R. Wheeler, Ph.D., do hereby declare and say as follows:

I. INTRODUCTION

1. I have personal knowledge of the facts contained in this Declaration, am of legal age, and am otherwise competent to testify.

2. 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. 11,799,131 (the “’131 Patent”).

3. I understand that Zhuhai CosMX Battery Co., Ltd. (“Petitioner”) filed a petition for *Inter Partes* Review (“IPR”) of the ’131 Patent (“Petition”), in which Petitioner asserts that:

- Claims 14-17 are obvious over Chinese Patent Application Publication No. 106099187A (“Zeng” or “Ex. 1006”) and U.S. Patent Application Publication No. 2015-0017542 (“Hirai” or “Ex. 1010”) (Ground 1A);
- Claims 14-17 are obvious over Zeng, Hirai, and U.S. Patent Application Publication No. 2013/0224535A1 (“Matsuoka” or “Ex. 1007”) (Ground 1B);

- Claims 14-17 are obvious over Zeng, Hirai, Matsuoka, and U.S. Patent Application Publication No. 2017/0288268A1 (“Kim ’268” or “Ex. 1008”) (Ground 1C);¹
- Claim 15 is obvious over Zeng, Hirai, and Japanese Patent Application No. JP 2018-78052 A (“Han” or “Ex. 1012”) (Ground 2A);
- Claim 15 is obvious over Zeng, Hirai, Han, and Matsuoka (Ground 2B);
- Claim 15 is obvious over Zeng, Hirai, Han, Matsuoka, and Kim (Ground 2C);²

¹ Petitioner considers Matsuoka to be optionally included as Petitioner asserts that “***Zeng/Hirai or Zeng/Hirai/Matsuoka***, further in view of Kim ’268, render obvious claims 14-17” such that Ground 1C constitutes two grounds. Pet., 58 (emphasis added); *see also*, Pet. 16 (“Zeng; Zeng/Matsuoka” with respect to Ground 1C).

² Petitioner considers Matsuoka to be optionally included as Petitioner asserts that “***Zeng/Hirai/Han or Zeng/Hirai/Matsuoka/Han***, further in view of Kim ’268, render obvious claim 15” such that Ground 2C constitutes two grounds. Pet., 58 (emphasis added); *see also*, Pet. 17 (“Zeng; Zeng/Matsuoka” with respect to Ground 2C).

- Claims 14-17 are obvious over Chinese Patent Application Publication No. CN 105552439A (“Zhou” or “Ex. 1014”) and Hirai (Ground 3A);
- Claims 14-17 are obvious over Zhou, Hirai, and Kim ’268 (Ground 3C);³
- Claim 15 is obvious over Zhou, Hirai, and Han (Ground 4A);
- Claim 15 is obvious over Zhou, Hirai, Han, and Kim ’268 (Ground 4C).⁴

4. I have been asked, for purposes of Patent Owner’s Preliminary Response, to analyze and respond to particular assertions in the Petition. I reserve the right to analyze and respond to other alleged patentability challenges if this proceeding is instituted.

5. As explained below, in my opinion, the Petition fails to show that claims 14-17 of the ’131 Patent are rendered obvious.

6. I am being compensated for my time spent on the present matter at my customary consulting rate of \$350 per hour for preparatory work and at my customary consulting rate of \$450 per hour for depositions/trial work. I am also

³ Notably, Petitioner did not assert a Ground 3B.

⁴ Notably, Petitioner did not assert a Ground 4B.

being compensated for expenses incurred as a result of activities performed as an expert. My compensation is in no way contingent on the nature of my opinions, the outcome of this or any other proceeding, or any of the issues involved therein. I have no other interest in this proceeding.

II. BASIS FOR OPINIONS

A. Qualifications

7. My qualifications and professional experience are described in my *curriculum vitae*, a copy of which is provided with this Declaration as Ex. 2016. The following is a brief summary of my qualifications and professional experience.

8. I am a university professor and consultant with 28 years of experience in the fields of electrochemical engineering, materials science, and manufacturing of battery materials. I received a B.S. in Chemical Engineering from Brigham Young University in 1996, and a Ph.D. in Chemical Engineering from the University of California, Berkeley, in 2002. My Ph.D. advisor was Professor John Newman, arguably the world's foremost leader in understanding battery materials through computer simulations. Under his direction, I acquired a deep understanding of the physics and chemistry of battery materials.

9. I have taught numerous classes on electrochemical engineering and materials science during my twenty-two years at Brigham Young University, as assistant professor, associate professor, and now, full professor. I currently serve as

the department chair in the Chemical Engineering Department of Brigham Young University, supervising sixteen faculty members and six full-time staff.

10. I am an inventor on two issued patents and one patent application in the field of electrochemical devices. For example, U.S. Patent No. 11,340,261, issued in 2022, describes a flexible electric probe used to determine electrical properties of thin-film battery electrodes.

11. I have also authored or co-authored 63 peer-reviewed scientific publications. My most influential paper, “Quantifying tortuosity in porous Li-ion battery materials,” published in the Journal of Power Sources in 2009, has been cited more than 600 times, and describes the movement of ions through various types of battery materials, including separator and electrode materials. I have also published papers on the subjects of electrode structures and compaction, interactions of solids, binders, and electrolytes, interfaces between electrodes and electrolytes, and how all these factors relate to battery longevity.⁵

⁵ See, e.g., Ex. 2028 (Amir-Sina Hamed, Fezzeh Pouraghajan, Fei Sun, Mojdeh Nikpour, & Dean R. Wheeler, *Interplay of Electrode Heterogeneity and Lithium Plating*, 169 J. Electrochem. Soc. 020551 (2022)); Ex. 2029 (Fei Sun and Dean R. Wheeler, *The Effects of Lithium Ions and pH on the Function of Polyacrylic*

12. I have received more than \$7 million in government research grants to study batteries and related materials. Current research grants from NASA and the U.S. Army deal with understanding and improving electrolyte formulations and interactions with anode and cathode materials. My student assistants and I regularly fabricate and analyze battery materials in the laboratory, using techniques comparable to those described in the '131 Patent and cited prior art references. In particular, we routinely mix up custom-formulated electrolyte solutions, fabricate cathodes and anodes, and construct and test full lithium-based batteries. My research group is among the top users of electron microscopy at the university, which we use to analyze and understand battery electrode and separator structures. We also routinely measure the properties of battery materials and develop new diagnostic

Acid Binder for Silicon Anodes, 170 J. Electrochem. Soc. 080502 (2023)); Ex. 2030 (Fezzeh Pouraghajan, Andrea I. Thompson, Emilee E. Hunter, Brian Mazzeo, Jake Christensen, Ram Subbaraman, Michael Wray, & Dean Wheeler, *The Effects of Cycling on Ionic and Electronic Conductivities of Li-ion Battery Electrodes*, 492 J. of Power Sources 229636 (2021)); Ex. 2031 (Amir-Sina Hamed, Edmund M. Shumway, & Dean R. Wheeler, *Electrode-Level Modeling of Silicon Anodes for Improved Cell Design*, 171 J. Electrochem. Soc. 120539 (2024)).

tools for making such measurements. Such training in my laboratory has allowed the students graduating from my program to go on to employment at numerous battery manufacturers and battery-related startup companies across the United States.

13. In 2016, I led the Gordon Research Conference on Batteries⁶ as conference chair, having been nominated and voted into that position at a previous conference. This biennial international conference is attended by around two hundred of the world's thought leaders in the field of batteries. Furthermore, on three occasions I was selected to be a member of the technical review team for an ongoing \$25 million/year "Battery Hub" program funded by the U.S. Department of Energy.⁷ I believe my experience in such positions of leadership and responsibility, among others, reflects the stature with which I am viewed by my peers in the academic, industrial, and government battery research communities.

⁶ See Ex. 2025 (2016 Batteries Conference GRC, <https://www.grc.org/batteries-conference/2016/> (last visited on May 12, 2025)).

⁷ See Ex. 2026 (*Hubs – Department of Energy*, <https://www.energy.gov/hubs> (last visited on May 12, 2025)); Ex. 2027 (*DOE Energy Innovation Hubs*, <https://science.osti.gov/bes/Research/DOE-Energy-Innovation-Hubs> (last visited on May 12, 2025)).

B. Materials Considered

14. 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.

15. 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.

16. As I discuss below, I disagree with Dr. Lucht's conclusions that the subject matter of any of claims 14-17 of the '131 Patent would have been obvious in view of the Grounds he has identified.

III. LEGAL STANDARDS

17. 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

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

19. 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.

20. 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.

21. I understand that in an *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.

22. 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

23. 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.

24. 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.

25. 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.

26. 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

27. 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.

28. 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.

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

30. 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.

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

32. Understanding that there are not any issues with respect to anticipation in this *inter partes* review, I focus my attention on obviousness.

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 have been informed and understand that an invention composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known or in the prior art, but that there must be an

apparent reason or motivation to combine the known elements in the fashion claimed by the patents at issue.

37. 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. I further understand that whether a proposed modification or combination of the prior art has a reasonable expectation of success is determined at the time the invention was made.

38. 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.

39. 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.

40. 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

41. In lithium-ion batteries, lithium ions shuttle back and forth between the negative and positive electrodes during cycling. During the first few cycles of the lithium-ion battery the electrolyte undergoes reduction at the 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 compounds and especially electrolyte decomposition or other reaction products. Battery performance,

irreversible charge loss, rate capability, cyclability, and safety are highly dependent on the quality of the SEIs.

42. 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 of each such component, can play a crucial role in determining the performance of the SEI.

43. 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.

44. The design rules for how to make a high-functioning SEI are still being discovered and explored, and the field remains highly empirical and Edisonian, in which researchers try many combinations to discover what works or does not work. To make an SEI that meets all objectives has never happened because the ultimate design goal is essentially a battery that lasts forever, meaning one has formed an SEI film on each electrode that perfectly protects the electrode and prevents any further degradation at operational conditions including temperature and voltage. The

difficulty of the task is amplified by the vastness of the design space in which researchers may select any number and relative amounts of electrolyte solvents, additives, and lithium-containing salts.

B. Electrode Compaction Density

45. The electrode is a film. The density of the final coating (in units of mass per volume) of an electrode film is controlled by two factors: (1) crystalline density and relative amounts of underlying solids and binder that make up the composite; and (2) porosity of the film. With respect to (1) crystalline density and relative amounts of underlying solids and binder that make up the composite, using a “rule of mixtures,” material scientists routinely can estimate the density of a solid composite of these materials at zero porosity. This represents the theoretical upper bound of density for a film made of this combination of materials. With respect to (2), the porosity of the film (i.e., volume fraction of pores or void space between solid materials) only scales the composite density *downward* from the theoretical upper bound of density of (1) (without any pores). Porosity is controlled by (i) the way the solid materials are arranged and applied to the substrate in the form of a liquid slurry that is coated and then dried; and (ii) the degree of calendering or compaction after the drying process, normally performed by rollers, which changes

the final film thickness, and therefore, the porosity. *See* Ex. 2041.⁸ After the compaction is performed, there might be some recovery or springback in which elastic forces cause the film to increase modestly in porosity from the minimum value imparted by the compaction process. The recovery process typically takes a brief period of time that depends on the timescale for viscoelastic relaxation of the polymeric materials used in the film. Temperature would be another factor controlling this process. Once this recovery is complete the porosity and hence density of the film will be stable until further manufacturing steps are undertaken.⁹

⁸ Ex. 2041 (M. Abdollahifar, H. Cavers, S. Scheffler, A. Diener, M. Lippke, A. Kwade, *Insights into Influencing Electrode Calendering on the Battery Performance*. Adv. Energy Mater. 2023, 13, 2300973. <https://doi.org/10.1002/aenm.202300973>).

⁹ Understanding density and porosity of battery materials is an area in which I have particular expertise. I have been performing such measurements and calculations across my entire career, including in publications given as Exs. 2028, 2030, 2031.

C. The '131 Patent

46. The '131 Patent describes an electrochemical device with a novel lithium-ion battery electrolyte solution that can provide a firm protective SEI film on the surface of the cathode of the 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, 1:55-62, 3:8-20. The '131 Patent achieves this by providing an electrolyte solution comprising a dinitrile compound, a trinitrile compound, and propyl propionate in specific weight percentage concentrations and mixing ratios. *Id.* 1:55-62, 27:16-19, 28:49-64.

47. The '131 Patent explains that a dinitrile compound can form a protective film (or SEI)¹⁰ on the cathode of the electrochemical device, so as to inhibit the decomposition of the electrolyte solvent in the electrochemical device. *Id.* 1:49-52. 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.* 1:52-55.

¹⁰ The "protective film" described in the '131 Patent is akin to the "SEI" described in Section IV.A.

48. The '131 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.* 22:24-29, 1:30-39; *see also* 1:32-37 (“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 '131 Patent further explains that “[p]rior to the present application, the primary solution [was] to add 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.* 21:32-37.

49. The inventors of the '131 Patent discovered that by using a mixture of a dinitrile compound, a trinitrile compound, and propyl propionate in specific concentration ranges and ratios, a firm SEI protective film that is not easily decomposed at a high potential of 4.45V and inhibit a DC internal resistance in the electrochemical device, could be formed on the surface of the cathode. *Id.* 1:55-60

(“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.”), 28:56-59 (“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.”), 28:59-64 (“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.”).

50. The '131 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.* 2:39-52, 2:16-24, 28:49-64.

51. The '131 Patent further explains that the electrode has an electrode compaction density. *Id.* 20:54. The electrode compaction density is obtained by measuring the thickness of an electrode using a precise measurement tool, such as a

ten-thousandths micrometer; then taking the electrode of a certain area and accurately measuring the area and weight; and calculating the electrode compaction density by the below formula:

Electrode Compaction Density

$$= \frac{(\text{Weight of electrode} - \text{Weight of current collector})}{\text{Area of electrode} \times (\text{Thickness of electrode} - \text{Thickness of current collector})}$$

52. Properly controlling the electrode compaction density of the single-sided and double-sided coating is important to obtaining electrochemical devices with high capacity density, and excellent cycle and storage performances. *Id.* 21:6-9. A lower compaction density makes the porosity higher, making some of the particles in an insulating state, and unable to participate in charge and discharge, thereby resulting in a low specific discharge capacity, thus affecting the performance of the electrochemical device. A too high compaction density may cause difficulty in infiltrability of the electrolyte and decrease in solution retention, such that the cycle and rate performances cannot be guaranteed. *Id.* 20:65-21:5.

53. The inventors of the '131 Patent discovered that by controlling the relationship of D1 and D2, the effects of the cathode and anode active materials are well exerted, so that the electrode can obtain good electrical conductivity, which is also important to control the expansion of electrochemical devices. Therefore, the obtained electrochemical device has high capacity density and excellent cycle and

storage performances. *Id.* 21:10-20; *see also*, 31:49-57 (“the electrode compaction density ratio (D1/D2) of the lithium ion battery has a significant effect on the cycle performance of the lithium ion battery. A too large or too small D1/D2 will damage the cycle performance of lithium-ion batteries. It can be seen that when D1/D2 is within the range of 0.8-1.2, a better cycle performance is obtained, possibly because the combined additives facilitate the reduction of the electrode interface resistance and the reduction of the cell polarization.”)

V. LEVEL OF ORDINARY SKILL IN THE ART

54. I understand that Petitioner provides the following definition of a POSITA:

A POSITA of the '131 Patent in September 2018 would have an 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. EX1003, ¶ 17; EX1001, 1:18-20. This skill level is approximate, and more experience could compensate for less formal education, and vice versa.

Pet., p. 15.

55. 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.

56. Each of the arguments below should be considered from the perspective of a POSITA in the field of the '131 Patent and during the relevant time frame (e.g., September 2018). During that time frame, I possessed at least the qualifications of a POSITA, as defined above. Furthermore, I am familiar with the level of skill in the art that a POSITA would have had at the time, as during the relevant time frame I regularly supervised, interacted with, and taught persons who had this level of skill.

VI. THE BOARD SHOULD NOT INSTITUTE INTER PARTES REVIEW

57. 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 1A: Zeng and Hirai Do Not Render Obvious Claims 14-17

58. Petitioner contends that Zeng and Hirai render obvious claims 14-17 of the '131 Patent. These claims recite:

14. An electrochemical device, comprising:
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; wherein,

about $2 \text{ wt } \% \leq (X+Y) \leq \text{about } 8 \text{ wt } \%$, and

about $0.1 \leq (X/Y) \leq \text{about } 6$; wherein,

the electrodes comprise a first electrode and a second electrode, wherein

the first electrode comprises a first current collector and a single-sided coating;

the second electrode comprises a second current collector and a double-sided coating; and

an electrode compaction density of the first electrode comprising the single-sided coating is D1, and, an electrode compaction density of the second electrode comprising the double-sided coating is D2, wherein, about $0.8 \leq D1/D2 \leq \text{about } 1.2$;

wherein based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z; wherein,

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

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.

15. The electrochemical device according to claim 14, wherein the first electrode is a cathode, the second electrode is a cathode, and $3.5 \text{ g/cm}^3 \leq D2 \leq 4.3 \text{ g/cm}^3$.

16. The electrochemical device according to claim 14, wherein the first electrode is an anode, the second electrode is an anode, and $1.2 \text{ g/cm}^3 \leq D2 \leq 1.8 \text{ g/cm}^3$.

17. The electrochemical device according to claim 14, 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.

59. I disagree that Zeng and Hirai render obvious any of claims 14-17 for at least the following reasons.

60. Dr. Lucht relies on the disclosure of Zeng for all elements of independent claim 14, except for element [14.4], which recites “wherein the electrodes comprise a first electrode and a second electrode,” element [14.5], which recites, *inter alia*, a single-sided coating and a double-sided coating, and element [14.6], which recites, *inter alia*, electrode compaction densities and an electrode compaction density ratio, for which Dr. Lucht allegedly relies on the disclosure of Hirai. Ex. 1003 ¶¶ 90-122.

61. Zeng is directed to a wide-temperature range homogenous non-aqueous electrolyte solution to provide certain performance advantages for the lithium-ion battery, the electrolyte solution using an additive combination that can “effectively protect the structural stability of positive and negative electrode materials, and has excellent solubility in the mixed solvent.” Ex. 1006, Abstract. Indeed, it is important to Zeng that the electrolyte solution “can be maintained even after storage for a long period of time in an environment below -30°C” such that it does not “precipitate crystals at low temperatures and facilitate[es] the transportation and long-term storage of the non-aqueous electrolyte solution in the north of China.” *Id.* Zeng describes 9 embodiments and 6 comparison examples of various electrolyte formulations conducts capacity retention rate performance and low-temperature storage (e.g., precipitation) testing on lithium-ion batteries made with these

electrolyte solutions to test the effect that the solvent systems and additive combinations have on performance and temperature range of the batteries:

Embodiment	Solvent composition	FEC (%)	ADN (%)	Structural formula I additives (%)	Other additives (%)	Retention rate (%) after 500 cycles at 1C rate for 4.40 V at ambient temperature	Precipitation of crystals after storage for 10 days at -30°C
Embodiment 1	EC: PC: DEC: FB: EP: PP =25: 10: 30: 5: 10: 20	4	2	T ₁ : 1 T ₂ : 0.5	VC: 0.2 PS: 4	91.2	No precipitation
Embodiment 2	EC: PC: DEC: FB: EP: PP =25: 10: 30: 5: 10: 20	4	1	T ₁ : 2 T ₂ : 0.5	VC: 0.2 PS: 4	91.9	No precipitation
Embodiment 3	EC: PC: DEC: FB: EP: PP =25: 10: 30: 5: 10: 20	4	2	T ₃ : 1 T ₂ : 0.5	VC: 0.2 PS: 4	90.8	No precipitation

Embodiment 4	EC: PC: DEC: FB: EP: PP =25: 10: 30: 5: 10: 20	4	2	T ₁ : 1 T ₂ : 0.5	VC: 0.2 PS: 4	91.0	No precipitation
Embodiment 5	EC: PC: DEC: FB: EP: PP =25: 10: 30: 5: 10: 20	5	2	T ₂ : 2	VC: 0.2 PS: 4	92.2	No precipitation
Embodiment 6	EC: PC: DEC: FB: EP: PP =25: 10: 30: 5: 10: 20	4	2	T ₁ : 1 T ₂ : 0.5	DTD: 0.5 PS: 3.5	91.6	No precipitation
Embodiment 7	EC: PC: DEC: FB: EP: PP =20: 15: 30: 5: 10: 20	4	2	T ₁ : 1 T ₂ : 0.5	VC: 0.2 PS: 4	90.3	No precipitation
Embodiment 8	EC: PC: DEC: FB: EP: PP =20: 10: 35: 5: 10: 20	4	2	T ₁ : 1 T ₂ : 0.5	VC: 0.2 PS: 4	91.5	No precipitation
Embodiment 9	EC: PC: DEC: FB: EP: PP =25: 10: 30: 5: 15: 15	4	2	T ₁ : 1 T ₂ : 0.5	VC: 0.2 PS: 4	90.8	No precipitation
Comparison Example 1	EC: PC: DEC: FB: EP: PP =25: 10: 30: 5: 10: 20	2.5	2	/	VC: 0.2 PS: 4	82.1	Small amount precipitated, main component ADN
Comparison Example 2	EC: PC: DEC: FB: EP: PP =25: 10: 30: 5: 10: 20	4	2	/	VC: 0.2 PS: 4	84.3	Small amount precipitated, main component ADN
Comparison Example 3	EC: PC: DEC: FB: EP: PP =25: 10: 30: 5: 10: 20	4	3.5	/	VC: 0.2 PS: 4	86.9	Large amount precipitated, main component ADN
Comparison Example 4	EC: DEC: FB: EP: PP=35: 30: 5: 10: 20	4	2	T ₁ : 1 T ₂ : 0.5	VC: 0.2 PS: 4	87.5	Precipitated, main components EC and ADN
Comparison Example 5	EC: PC: DEC=30: 20: 50	4	2	T ₁ : 1 T ₂ : 0.5	VC: 0.2 PS: 4	79.9	Precipitated, main components EC and ADN
Comparison Example 6	EC: PC: DEC: FB=30: 15: 50: 5	4	2	T ₁ : 1 T ₂ : 0.5	VC: 0.2 PS: 4	81.1	Precipitated, main components EC and ADN

Id. ¶¶ [0039]-[0043], Table 1.

62. Zeng is directed to a fundamentally different problem than the '131 Patent. Unlike Zeng, the '131 Patent's claims are directed to three components—a dinitrile compound, a trinitrile compound, and propyl propionate—combined in specific weight percentage ratio ranges that unexpectedly provided the benefit of forming 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 4.45V and effectively reduce DC internal resistance of the battery. Ex. 1001 at 1:55-62 (“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”). Indeed, as set forth in the '131 Patent, “[t]he 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.” Ex. 1001, 28:59-64. Zeng is silent about this critical formula and how the specific interactions of these three compounds in the critical formulations can

effectively inhibit the increase in DC internal resistance of the electrochemical device.

63. Instead of identifying any 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, it is my understanding that Petitioner points to the electrolyte compositions disclosed for Embodiments 4 and 6 in Table 1 of Zeng, and alleges that these electrolyte compositions render obvious the claimed electrolyte composition of claim 14. *See* Pet., pp. 18-26 and 43-44.

64. For the reasons below, it is my opinion that a POSITA would not have selected or implemented Embodiments 4 and/or 6 of Zeng. It is also my opinion, for the reasons below, that the disclosure of Zeng does not provide sufficient detail that would allow the POSITA to determine that Zeng discloses or renders obvious the claimed ratio of trinitrile to propyl propionate (Y/Z) of independent claim 14, as evidenced by at least the numerous unsupported and incorrect assumptions, calculations, and arguments made by Dr. Lucht. Nor does Zeng disclose, or Petitioner/Dr. Lucht identify disclosure, that overcomes the criticality of the claimed Y/Z ranges.

65. As noted above, Dr. Lucht relies on the disclosure of Hirai for elements [14.4]-[14.6]. Ex. 1003 ¶¶ 90-122.

66. Hirai is directed to a laminated-structure battery. Ex. 1010, Title. In particular, Hirai is focused on “suppressing output unevenness of the single cells at a center portion and an end portion [of a laminated-structure battery] and improving durability by making the A/C ratio [the capacity ratio of the anode capacity to the cathode capacity] at the center portion in the direction of lamination higher than the A/C ratio at the end portion.” Ex. 1010 ¶ [0010].

67. After describing six means for allegedly making the A/C ratios of single battery layers higher closer to the center portion of a laminated-structure battery as compared to the end portion in the direction of lamination, Hirai describes 6 examples and 2 comparative examples of laminated-structure batteries comprising five layers of single battery layers, each of the single battery layers including a $\text{Li}(\text{Ni}_{0.8}\text{Co}_{0.1}\text{Al}_{0.1})\text{O}_2$ (NCA) cathode, a natural graphite anode, and an EC:DEC (5:5 molar ratio) electrolyte layer and conducts capacity retention and energy density testing with respect to each example/comparative example:

TABLE 17

	Capacity retention (500 cyc)	Energy density
Example 1	83%	92
Example 2	80%	92
Example 3	80%	93
Example 4	81%	91
Example 5	82%	100
Example 6	80%	100

TABLE 17-continued		
	Capacity retention (500 cyc)	Energy density
Com. Ex. 1	76%	85
Com. Ex. 2	74%	100

Ex. 1010 ¶ [0286], Table 17.

68. Hirai is directed to a fundamentally different problem than the '131 Patent. Unlike Hirai, the '131 Patent's claims are directed to three components—a dinitrile compound, a trinitrile compound, and propyl propionate—combined in specific weight percentage ratio ranges that unexpectedly provided the benefit of forming 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 4.45V and effectively reduce DC internal resistance of the battery. Ex. 1001 at 1:55-62, 28:59-64. Moreover, the '131 Patent describes a synergistic effect between the combined electrolyte additives and the electrode compaction density ratio. Ex. 1001, 31:53-57 (“It can be seen that when D1/D2 is within the range of 0.8-1.2, *a better cycle performance is obtained, possibly because the combined additives facilitate the reduction of the electrode interface resistance and the reduction of the cell polarization.*”) (emphasis added). Hirai is silent with respect to this critical formula and any such synergistic effect of the combined electrolyte additives and the electrode compaction density ratio. Accordingly, Hirai is simply

focused on purportedly addressing output unevenness to improve performance. Hirai is not concerned with any synergistic effect between electrolyte additives and electrode compaction density ratio as compared to the '131 patent.

69. For the reasons below, it is also my opinion that Hirai fails to disclose the claimed “electrode compaction density of the first electrode comprising the single-sided coating is D1” and, in turn, the claimed electrode compaction density ratio (D1/D2).

70. It is also my opinion that a POSITA would not be motivated to combine Hirai with Zeng.

1. Petitioner Fails to Show that a POSITA Would Have Selected or Implemented Embodiments 4 or 6 of Zeng

71. Zeng provides an electrolyte solution that “ensure[s] that a lithium-ion battery has good high-voltage cycle performance.” Ex. 1006 ¶ [0008]. To that end, Zeng prepares and tests batteries using the electrolyte solutions of Embodiments 1-9 and Comparative Examples 1-6, determining the capacity retention rate at the 500th cycle for each prepared battery:

[0039] High-voltage battery electrical performance testing:

[0040] The lithium-ion battery electrolyte solution prepared in the steps described above is injected into a

fully dried 4.40 V graphite/LiCoO₂ polymer battery; the battery is set aside at 45°C, and formed in a high-temperature fixture and sealed twice, then conventional classification of capacity is performed.

[0041] At 25°C, the capacity-classified battery is charged with constant current and voltage at 1C to 4.40 V, the cut-off current being 0.02C, and is then discharged at 1C constant current to 3.0 V. After 500 cycles of charging/discharging, the capacity retention rate at the 500th cycle is calculated. The calculation formula is as follows:

[0042] 500th cycle capacity retention rate (%) = (500th cycle discharge capacity / first cycle discharge capacity) × 100%

Ex. 1006 ¶¶ [0039]-[0042].

72. Dr Lucht opines that the selection of Embodiments 4 and 6 would have been obvious to a POSITA. Ex. 1003 ¶¶ 80-85. Not so. Dr. Lucht cherry-picks Embodiments 4 and 6 from the 15 embodiments explicitly disclosed by Zeng and the thousands of embodiments which would fit within the ranges described in Zeng. In fact, Zeng is silent regarding why the two embodiments selected by Dr. Lucht

provide benefits that would distinguish them from any of the remaining potential embodiments.

73. Regardless, Dr. Lucht asserts that “Zeng teaches, suggests, and motivates a POSITA to use the Embodiment 4 and 6 electrolytes” because the batteries of Embodiments 4 and 6 allegedly “significantly outperformed the Comparative Examples batteries in capacity retention...[and] outside of Embodiments 2 and 5, Embodiment 6 had the best capacity retention at 91.6%” and it is Dr. Lucht’s opinion that “these superlative results would have motivated the POSITA to implement at least Embodiments 4 and 6.” Ex. 1003 ¶ 81. I disagree that “Zeng teaches, suggests, and motivates a POSITA to use the Embodiment 4 and 6 electrolytes” at least because there is no unambiguous data of the embodiments of Zeng that would indicate to or encourage a POSITA to choose *any* particular embodiment of Zeng over another. *See e.g.*, Ex. 1006 ¶¶ [0045]-[0046] (each of Embodiments 1-9 reflecting a similar capacity retention rate within a nominal 2% range (i.e., between 90.3-92.2%) and no precipitation of crystals after low-temperature storage for 10 days).

74. Moreover, Zeng offers no guidance to a POSITA as to why Embodiments 4 and 6 would be chosen. Indeed, in Dr. Lucht’s attempts to parse the ambiguous data to try to manufacture some distinction or suggestion to use

Embodiments 4 and 6 in Zeng, Dr. Lucht fails to appreciate that the POSITA would actually interpret the addition of a trinitrile compound in Zeng as *negatively* impacting the capacity retention rate. That is, Embodiments 2 and 5, which Dr. Lucht admits had better capacity retention rates (91.9% and 92.2%, respectively) than both Embodiments 4 and 6 (91.0% and 91.6%, respectively), contained dinitrile compound(s) but did not contain *any* trinitrile compound. Ex. 1006 ¶¶ [0045]-[0046]; *see also* Ex. 1003 ¶ 81. Embodiments 1 and 8, which also had a better capacity retention rates (91.2% and 91.5%, respectively) than Embodiment 4, also contained dinitrile compound(s) but did not contain *any* trinitrile compound. Ex. 1006 ¶¶ [0037], [0045]-[0046]. A POSITA would therefore interpret Zeng as teaching that the addition of a trinitrile compound is a factor that *lowers* capacity retention rate. Because capacity retention is an important aspect to Zeng in “the development of high-energy density lithium-ion batteries” (Ex. 1006 ¶ [0003]), such lower capacity retention rates relative to Embodiments 2, 5, and/or 8, would deter the POSITA from selecting Embodiments 4 and 6 in Zeng and teach away from selecting those embodiments.

75. Even if a POSITA were to select Embodiment 4 or 6 of Zeng (which it is my opinion that a POSITA would not make such selection), the negative impact of the trinitrile compound on the capacity retention rates of Embodiments 4 and 6

relative to Embodiments 1, 2, 5, and/or 8 would also *teach away* from considering the relation or adjustment of a trinitrile compound to propyl propionate ratio (Y/Z) other than to eliminate the amount of trinitrile compound in Zeng's Embodiments 4 and 6 to zero, as in Embodiments 1, 2, 5, and 8.

76. In support of his obviousness rationale related to Embodiments 4 and 6 of Zeng, Dr. Lucht also opines that “[e]ach embodiment in Zeng is a self-contained, working embodiment providing a complete list of components, component amounts, and instructions needed to make Zeng’s electrolyte solution.” Ex. 1003 ¶ 80. I disagree at least because the components and component amounts present in Embodiments 2-9 and Comparison Examples 1-6 are ambiguous, deterring the POSITA from implementing any of such embodiments/examples of Zeng. For example, Paragraphs [0043] and [0044] of Zeng provide:

[0043] Embodiments 2-9 and Comparison Examples 1-6
[0044] In Embodiments 2-9 and Comparison Examples 1-6. Other than the electrolyte solution solvent and some additive composition and content *added as shown in Table 1*, all else is the same as in Embodiment 1. *Table 1 lists the electrolyte solution partial component content*, battery performance testing results, and low temperature storage of Embodiments 1-9 and Comparison Examples 1-6.

Ex. 1006 ¶¶ [0043]-[0044] (emphases added).

77. The phrases “**added as shown in Table 1**” and “**electrolyte solution *partial component content***” in Paragraph [0044] indicate to a POSITA that Embodiments 2-9 and Comparison Examples 1-6, including Embodiments 4 and 6, contain the components identified in Table 1 *and* the components set forth in Embodiment 1 (i.e., at Paragraph [0037]), resulting in each Embodiment or Example constituting an amalgamation of indeterminable amounts of solvent compositions and additives.

78. In addition, as set forth in more detail below in Section VI.A.2.a., the instructions needed to make Zeng’s electrolyte solutions as set forth in Paragraph [0037] of Zeng fail to provide in which solvent the lithium hexafluorophosphate (LiPF_6) is dissolved or how much of such 1.0 mol/L salt solution is added to form Zeng’s electrolyte solutions such that a POSITA would not be led to select or implement Embodiments 4 and 6 of Zeng.

79. Dr. Lucht provides his opinion that “[a]t the very least..., it would have been ‘obvious to try’ Zeng Embodiments 4 and 6.” Ex. 1003 ¶ 82. I disagree with Dr. Lucht that it would have been obvious to try Embodiments 4 and 6 of Zeng in the manner proposed by Dr. Lucht.

80. Dr. Lucht alleges that “Zeng observes a market need for ‘high-energy density lithium-ion batteries’ driven by ‘consumer terminals demand[ing] ever-

higher energy density from batteries” and further asserts that Zeng “sought a well-rounded dinitrile- and trinitrile-based ‘electrolyte solution that can remain homogenous and stable over a wide temperature range in order to ensure that a lithium-ion battery has good high-voltage cycle performance and can perform at high and low temperatures.” Ex. 1003 ¶ 83 (citing Ex. 1006 ¶¶ [0008]-[0009]). First, Zeng did not seek or otherwise require a “dinitrile- and trinitrile-based ‘electrolyte solution’” as asserted by Dr. Lucht because (1) the structural formula I of Zeng is not required to be a trinitrile, and (2) as discussed *supra* in Paragraphs 74-75, a POSITA would interpret Zeng as teaching that the addition of a trinitrile compound is a factor that *lowers* capacity retention rate. Second, such alleged “recognized need in the art” materially differs from the problem that the inventors of the ’131 Patent faced. The ’131 Patent is directed to solving the problem of how to address the decrease of battery capacity in the context of electrochemical devices with a working voltage above 4.4 V and effectively reduce DC internal resistance of the electrochemical device. Ex. 1001, 1:55-62. For example, “[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.” Ex. 1001, 22:24-29.

81. Contrary to Dr. Lucht's further allegations of a "[f]inite number of identified, predictable solutions" and assertion that "Zeng only discloses nine electrolyte solutions (Embodiments 1-9), [] all demonstrat[ing] better capacity retention over 500 cycles and low-temperature performance than the electrolytes of the Comparative Examples" (Ex. 1003 ¶ 84), a POSITA would have understood that there were many potential solutions to the problem faced by the inventors of the '131 Patent, not a finite number of identified, predictable solutions because the requirements in the battery art are so challenging and varied from application to application, the set of possible electrolyte compounds and combinations is effectively infinite, and the outcomes unpredictable.

82. To illustrate this complexity, I briefly outline the chemical and mechanical requirements for a solution to the high-voltage SEI problem. For example, multiple electrolyte components must oxidize on the cathode to form the SEI constituents but can be advantageous only if the combination of reactions are inherently self-limiting and therefore stop after a short period of time. Otherwise, an indefinitely ongoing reaction at the cathode will cause the cell to self-discharge, capacity to be lost, DC resistance to continually increase, or any combination of the same. Furthermore, the products of these oxidation reactions must be insoluble in the remaining electrolyte so as to form a solid film on the surface, the film must be

mechanically stable in spite of volume changes in the underlying cathode material, and the film must allow the permeability of lithium ions but not the passage of electrons. Finally, any unreacted additives or other electrolyte components must function as a suitable electrolyte. Among other things, these components must, across a range of temperatures, be mutually soluble, function as a satisfactorily facile carrier of the lithium salt, and meet safety and price constraints.

83. While all the above requirements would be well known to a POSITA, simultaneously meeting these requirements requires extensive tradeoffs and careful balance of competing effects, with no guarantee of finding a satisfactory “sweet spot.” Therefore, generating a high-voltage passivated cathode surface having all these requirements is practically a miracle, leading to longstanding unmet need. Not to mention that the desired sweet spot could vary from one practitioner to another depending on the envisioned application for their battery technology. A POSITA would have therefore understood that there are a very large number of potential solutions to the identified problem, each of which vary in terms of which characteristics are emphasized and which are “traded away” for other characteristics.

84. Similar to Dr. Lucht’s prior assertion that “Zeng teaches, suggests, and motivates a POSITA to use the Embodiment 4 and 6 electrolytes” because the batteries of Embodiments 4 and 6 “significantly outperformed the Comparative

Examples batteries” and “outside of Embodiments 2 and 5, Embodiment 6 had the best capacity retention,” Dr. Lucht purports to support his opinion that there are a “[f]inite number of identified, predictable solutions” and it would have been “obvious to try” Embodiments 4 and 6 of Zeng with the assertion that “Embodiments 4 and 6 would have been considered strong options, given that Embodiment 6 performed above average (91.6% vs. 91.2%) in capacity retention and Embodiment 4 performed about average (91.0%).” Ex. 1003 ¶ 84. As I explained *supra* in Paragraphs 74 and 75 of this Declaration, however, the lower capacity retention rates of Embodiments 4 and 6 relative to Embodiments 1, 2, 5, and/or 8 would actually deter the POSITA from implementing Embodiments 4 and 6. *Supra*, ¶¶ 74-75. Indeed, far from an “obvious to try”, Zeng’s teachings about the comparatively negative impact of the trinitrile compound on the capacity retention rates of Embodiments 4 and 6 would teach the POSITA away from considering the relation or adjustment of a trinitrile compound to propyl propionate ratio (Y/Z) in Zeng’s embodiments. *Id.*

85. Dr. Lucht further purports to support his opinion that it would have been obvious to try Embodiments 4 and 6 of Zeng with the assertion that “Zeng also provides detailed preparation instructions to make the electrolytes” (Ex. 1003 ¶ 85), however, as discussed in detail in Section VI.A.2.a., *infra*, the instructions needed

to make Zeng's electrolyte solutions as set forth in Paragraph [0037] of Zeng fail to provide *which* solvent the lithium hexafluorophosphate (LiPF_6) is dissolved or *how much* of such 1.0 mol/L salt solution is added to form Zeng's electrolyte solutions such that a POSITA would not be led to select or implement Embodiments 4 and 6 of Zeng, let alone any embodiment of Zeng.

86. Thus, I disagree with Dr. Lucht's suggestion that a POSITA reading the Zeng reference would have been motivated to select or implement Embodiments 4 and/or 6 of Zeng, let alone reach the same solution at which the inventors of the '131 Patent arrived.

**2. Petitioner Fails to Show that Zeng and Hirai Render
Obvious the Claimed Y/Z Ratio of Independent Claim 14**

87. Independent claim 14 requires, *inter alia*, "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;...wherein based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z; **wherein, about $0.01 \leq (Y/Z) \leq \text{about } 0.3$.**" Ex. 1001, 35:46-36:14 (emphasis added). Petitioner equates "wherein based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z; wherein, **about $0.01 \leq (Y/Z) \leq \text{about } 0.3$** " to claim element [14.7]. Pet. at ix ("Claims Appendix").

88. Neither Petitioner nor Dr. Lucht rely on Hirai in their obviousness rationale related to element [14.7]. Instead, Dr. Lucht opines that Zeng discloses or suggests element [14.7]. Ex. 1003 ¶¶ 123-125. Thus, element [14.7] rises and falls based on Zeng.

89. Dr. Lucht asserts that “in Zeng Embodiments 4 and 6, Y/Z is respectively greater than $1/17.66=0.057$ and $1/17.70=0.056$, overlapping the claimed range of about 0.01 to about 0.3.” *Id.*, ¶ 123.

90. Embodiments 4 and 6 of Zeng are very different from the electrolyte solutions claimed in the '131 Patent, and each of Embodiments 4 and 6 of Zeng comprises numerous additional components, including organic solvents, additives, and electrolytes. Specifically, Zeng discloses that each of the electrolyte solutions of Embodiments 4 and 6 includes at least:

- A mixture of six organic solvents comprising ethylene carbonate (EC), propylene carbonate (PC), diethyl carbonate (DEC), ethyl propionate (EP), propyl propionate (PP), and fluorobenzene (FB). Ex. 1006 ¶¶ [0011]-[0016], [0036]-[0037], [0043]-[0047]. For these organic solvents, Zeng provides a relative mass ratio of each organic solvent based on the total mass of the organic solvents. *Id.*
- An “additive combination.” *Id.* ¶¶ [0036]-[0037], [0043]-[0049]. For each additive, Zeng provides a weight percentage concentration on the basis of the total weight of the electrolyte solution. *Id.*

- Lithium hexafluorophosphate (LiPF₆). *Id.* ¶¶ [0036]-[0037], [0043]-[0049]. Zeng provides a molarity (mol/L) concentration of a LiPF₆ salt solution, which is equivalent to the number of moles of the LiPF₆ electrolyte salt divided by the total volume of the LiPF₆ salt solution. *Id.*

91. Table 1 below, excerpted from Zeng's Table 1, presents the components and concentrations of the various electrolyte components that Zeng discloses for Embodiments 4 and 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. In addition, "lithium hexafluorophosphate [LiPF₆] of a concentration of 1.0 mol/L is slowly added to the mixed solution." Ex. 1006 ¶ [0037].

Embodiment	Solvent Composition	FEC (%)	ADN (%)	Structural formula I additives (%)	Other additives (%)	Retention rate (%) after 500 cycles at 1C rate for 4.40 V at ambient temperature	Precipitation of crystals after storage for 10 days at -30°C
Embodiment 4	EC:PC: DEC:FB:EP:PP =25:10:30:5:10:20	4	2	T ₄ : 1 T ₂ : 0.5	VC : 0.2 PS: 4	91.0	No precipitation
Embodiment 6	EC:PC: DEC:FB:EP:PP =25:10:30:5:10:20	4	2	T ₄ : 1 T ₂ : 0.5	DTD: 0.5 PS: 3.5	91.6	No precipitation

Table 1. Zeng's Embodiments 4 and 6.

92. The weight percentage of propyl propionate based on the total weight of the electrolyte (Z) is necessary for the claimed Y/Z ratio. Zeng never explicitly discloses the weight percentage of propyl propionate or the ratio of trinitrile compound to propyl propionate in the final electrolyte solutions of Embodiments 4 and 6. Compare Ex. 1006, Table 1, with Ex. 1001, Claim 14 (“based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z; wherein, about $0.01 \leq (Y/Z) \leq \text{about } 0.3$.”). Nor does Zeng provide sufficient information from which a POSITA could determine the weight percentage of propyl propionate or the ratio of trinitrile compound to propyl propionate in the final electrolyte solutions of Embodiments 4 and 6 of Zeng. Indeed, Zeng does not teach, disclose, or suggest, in Table 1 or anywhere else, a *weight percentage* of propyl propionate *based on a total weight of the electrolyte solution* as claimed, but rather, discloses a relative *mass ratio* of each “electrolyte solvent partial component content” in the base solvent mixture based on the total mass of the solvent components. Ex. 1006 ¶¶ [0036]-[0037], [0043]-[0046]; *see also*, Ex. 1003 ¶ 66 (Dr. Lucht acknowledging the *mass ratio* disclosure of the solvent components of Zeng). Additives, such as vinylene carbonate (VC) and 1,3-propane sultone (PS), are “added on the basis of the total weight of the electrolyte solution” and if the inventors of Zeng had intended to focus on weight percent of propyl propionate (PP) in the total electrolyte, they would have

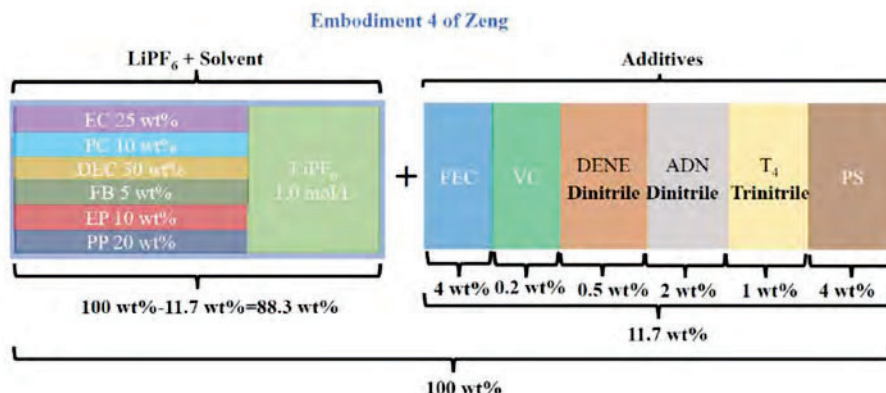
done so in the same way as VC and PS are expressed (i.e., “on the basis of the total weight of the electrolyte solution”).

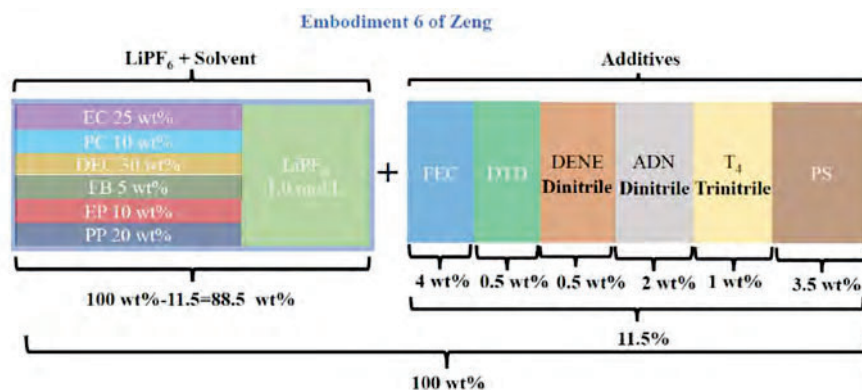
93. That is, despite Embodiments 4 and 6 of Zeng comprising various additional components and having three different types of concentration units—mass ratio of the organic solvents, weight % based on the final electrolyte solution weight, and molarity (mol/L) of the salt solution—which are respectively based on different measurements (total mass of the organic solvents, total weight of the electrolyte solution, and total volume of the LiPF_6 salt solution), Zeng does not provide those measurements (i.e., the total mass, total weight, or total volume), which would be necessary for a POSITA to even attempt to calculate a theoretical weight percentage of the propyl propionate component based on the total weight of the electrolyte solution or a ratio of a trinitrile compound to the propyl propionate component. Indeed, Zeng is not even concerned about the mass of organic solvents, as all Zeng discloses is a *mass ratio between solvents*. Ex. 1006 ¶¶ [0036]-[0037], [0045]-[0046]. As explained in more detail below in Section VI.A.2.a., it is also not apparent from the disclosure of Zeng in which solvent its indeterminate amount of LiPF_6 solution is dissolved before being added to the solvent mixture.

94. Despite this lack of sufficient disclosure, Dr. Lucht makes numerous unsupported and speculative assumptions to theoretically calculate an alleged weight

percentage of propyl propionate (Z) and, in turn, an alleged ratio of trinitrile compound to propyl propionate (Y/Z) in the final electrolyte solutions of Embodiments 4 and 6 of Zeng. Indeed and as described in Section VI.A.2.a., *infra*, at least one assumption underlying Dr. Lucht's calculations is diametrically opposed to the actual wording and teachings of Zeng.

95. To arrive at his alleged Y/Z values of >0.057 and >0.056 for Embodiments 4 and 6, respectively (Ex. 1003 ¶ 123), it is my understanding that Dr. Lucht asserts that the electrolyte solutions of Embodiments 4 and 6 have the following compositions:





Ex. 1003 ¶ 70.

96. I understand that based on such alleged compositions set forth above, Dr. Lucht asserts that “Zeng Embodiments 4 and 6 both have less than 20 wt% in the total electrolyte” (Ex. 1003 ¶ 67) and opines that Embodiments 4 and 6 contain a “maximum weight percentage in the total electrolyte” of 17.66 wt% and 17.70 wt %, respectively, of propyl propionate in the final electrolyte solutions of Embodiments 4 and 6. Ex. 1003 ¶ 73.

97. To obtain such “maximum weight percentage” for PP, I understand Dr. Lucht to have assumed (1) that propyl propionate forms 20 wt% of each solvent mixture, (2) that LiPF₆ is added in solid form to the solvent mixture, (3) that LiPF₆ and the solvent mixture form 88.3 wt% and 88.5 wt%, respectively, of the total electrolyte solutions of Embodiments 4 and 6, and (4) that “LiPF₆ has zero weight”:

$$88.3\% * \left(\frac{20}{25 + 10 + 30 + 5 + 10 + 20} \right) = 17.66\% \quad \text{Embodiment 4}$$

$$88.5\% * \left(\frac{20}{25 + 10 + 30 + 5 + 10 + 20} \right) = 17.70\% \quad \text{Embodiment 6}$$

Ex. 1003 ¶ 73.

98. Based on the further assumption that “any amount of LiPF₆ has a weight,” it is also my understanding that Dr. Lucht opines that propyl propionate is “less than 17.66 wt%” in Embodiment 4 and “less than 17.70 wt%” in Embodiment 6, but that “PP could not be diluted (i.e., Z could not be reduced) to a value that pushes Zeng Embodiments 4 and 6 outside the scope of the Challenged Claims without creating an atypical solution inconsistent with Zeng’s disclosure and lithium-ion batteries generally.” Ex. 1003 ¶¶ 73-74. For example, Dr. Lucht asserts that “diluting PP (i.e., reducing Z) to 5 wt% of the total electrolyte (low end of Z range recited in claim 7, which is not included in this Petition) would make the solvent just 25 wt% of the total electrolyte,” allegedly resulting in LiPF₆ constituting 63.5 wt% and 63.3 wt%, respectively, of Embodiments 4 and 6. *Id.*, ¶¶ 75-77.

99. With respect to the claimed upper limit of Y/Z of 0.3, Dr. Lucht opines that “both Zeng Embodiments’ Y/Z ratios fall below the claimed upper limit of 0.3” based on a similarly incorrect assumption that to “achiev[e] a Y/Z ratio of 0.3 or more would require Z to be 1/0.3=3.33 wt% or less” and “diluting PP (i.e., reducing Z) from 20 wt% of the solvent to 3.33 wt% of the total electrolyte reduce the solvent to

just 16.65 wt% of the total electrolyte,” allegedly resulting in LiPF_6 constituting “nearly five times the (typical) 1.0 mol/L specified by Zeng.” Ex. 1003 ¶ 124.

100. In a separate attempt to argue that there could not be such amounts of LiPF_6 present in the electrolyte mixture, Dr. Lucht proceeds to estimate a molarity of the hypothetical electrolyte composition that is based on several untested assumptions and simplifications, namely the wt% of the additives is completely ignored, the density of the solvent mixture is approximated without consideration of the actual composition and nonideality of the mixture, the unknown and notable contribution of the LiPF_6 salt to the solution volume is approximated without justification, and finally, a central assumption is made that such hypothetical electrolyte composition would be prepared at room temperature. *Id.*, ¶ 92. In spite of this convoluted effort to argue from absurdity, Dr. Lucht’s opinions as to a lower limit or diluted PP weight percentage necessarily fail.

101. *First*, Dr. Lucht fails to consider that propyl propionate is not even required to be present in Zeng. That is, as discussed in the criticality section, Section VI.A.2.b., *infra*, the presence of propyl propionate is not considered necessary or even required in Zeng such that the amount of propyl propionate in an electrolyte solution of Zeng may permissibly be zero. *See e.g.*, Ex. 1006 ¶ [0015] (“ $10\% \leq \text{ethyl propionate (EP)} + \text{propyl propionate (PP)} \leq 50\%$ ”), ¶ [0032] (“with the aid of the

property of low viscosity of carboxylic acid ester”), claim 1. For example, an electrolyte solution of Zeng may contain 10%-50% EP and **0% PP**. Indeed, Zeng identifies the carboxylic acid ester with respect to “the aid of the property of low viscosity of carboxylic acid ester.” Ex. 1006 ¶ [0032]. However, compared to EP, PP has a larger molecular mass and longer chain, which leads to a higher viscosity than EP, such that the POSITA would be motivated to decrease the amount of PP or completely replace PP with EP. Accordingly, Zeng Embodiments 4 and 6 can be diluted to a Z value below 5 wt% or even removed to a Z value of 0 wt%.

102. *Second*, Dr. Lucht’s assumptions that “diluting PP (i.e., reducing Z) to 5 wt% of the total electrolyte (low end of Z range recited in claim 7, which is not included in this Petition) **would make the solvent just 25 wt% of the total electrolyte,**” (Ex. 1003 ¶ 75) (emphasis added) and “diluting PP (i.e., reducing Z) from 20 wt% of the solvent to 3.33 wt% in the total electrolyte **would reduce the solvent to just 16.65 wt% of the total electrolyte,**” (Ex. 1003 ¶ 124) (emphasis added) are also wrong because as discussed in Section VI.A.2.a., *infra*, Dr. Lucht fails to account for the amount of unknown solvents that would necessarily be added by the 1.0 mol/L LiPF₆ salt solution. In other words, propyl propionate will be diluted by the addition of the 1.0 mol/L LiPF₆ salt solution, but the solvent weight percentage of the total electrolyte would not be “just 25 wt% of the total electrolyte”

or “just 16.65 wt% of the total electrolyte” because the addition of the 1.0 mol/L LiPF_6 salt solution would also necessarily include the addition of the unknown solvent components of the 1.0 mol/L LiPF_6 solution.

103. 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 provision by Zeng of the information necessary for a calculation of the weight percentage of propyl propionate based on the total weight of the electrolyte (e.g., measurements of the total mass of the organic solvent, total weight of the final electrolyte solution, or total volume of the LiPF_6 salt solution), it is my opinion that Dr. Lucht cannot directly and accurately calculate a weight percentage of propyl propionate and it is improper for Dr. Lucht or anyone to conclude that a POSITA could determine that Zeng discloses such weight percentage of propyl propionate, and in turn, the claimed ratio of the content of the trinitrile compound to the content of propyl propionate based on Zeng’s disclosures.

a. Dr. Lucht’s Assumption That LiPF_6 Is Added As A Solid In Zeng Is Unjustified

104. In his calculation of the alleged weight percentage of propyl propionate in Embodiments 4 and 6 of Zeng, Dr. Lucht relies on an unfounded and tenuous interpretation of the disclosure of Zeng that is diametrically opposed to the very

wording and teaching of the document. Specifically, Paragraph [0037] of Zeng recites:

[0037] Electrolyte solution preparation steps: in a glove box filled with argon gas, ethylene carbonate, propylene carbonate, diethyl carbonate, fluorobenzene, ethyl propionate, and propyl propionate are mixed at a mass ratio of EC:PC:DEC:FB:EP:PP = 25:10:30:5:10:20; ***then, lithium hexafluorophosphate of a concentration of 1.0 mol/L is slowly added to the mixed solution***, finally, the following are added on the basis of the total weight of the electrolyte solution: 4wt% of fluoroethylene carbonate (FEC), 2wt% of adiponitrile (ADN), 1wt% of succinonitrile (SN), 0.5wt% of 1,2-bis(2-cyanoethoxy)ethane (DENE), 0.2wt% of vinylene carbonate (VC), and 4.0wt% of 1,3-propane sultone; after stirring well, the lithium-ion battery electrolyte solution of Embodiment 1 is obtained.

Ex. 1006 ¶ [0037] (emphasis added).

105. It is immediately apparent from the text of Paragraph [0037] that the inventors of Zeng make a clear distinction as to how certain components are to be added to the electrolyte composition. For example, with respect to the additive components (such as adiponitrile or succinonitrile), Zeng explicitly states that their addition is “on the basis of the total weight of the electrolyte solution.” Ex. 1006

¶ [0037]. And with respect to lithium hexafluorophosphate (LiPF_6), Zeng explicitly states that its addition is *at a certain concentration*, such that the POSITA would understand that the lithium hexafluorophosphate salt of Zeng is necessarily added in the form of a solution. That is, the terms “of a concentration” and “mol/L”, which are indisputably present in the Zeng specification, necessarily require the existence of a solution with respect to the lithium hexafluorophosphate salt—not a solid. Specifically, Zeng recites that LiPF_6 “*of a concentration of 1.0 mol/L* is slowly added to the mixed solution.” *Id.* (emphasis added). Nowhere does Zeng state or imply, as Dr. Lucht suggests, that such “of a concentration of 1.0 mol/L” is an intended final concentration of the electrolyte solution or some specified concentration of the electrolyte solution *before* the subsequent addition of the additive combination). That is, for the addition of lithium hexafluorophosphate, no final concentration of the total electrolyte solution is specified by Zeng, only an addition of the lithium hexafluorophosphate salt solution that has a certain concentration.

106. Despite the actual text of Zeng, Dr. Lucht instead asserts, in a footnote, “a POSITA would understand [Zeng’s recitation of ‘then, lithium hexafluorophosphate of a concentration of 1.0 mol/L is slowly added to the mixed solution’] to mean adding solid LiPF_6 to the specified EC:PC:DEC:FB:EP:PP

solvent mixture *to reach a concentration of 1.0 mol/L.*” Ex. 1003 ¶ 66, fn. 6 (emphasis added). These unsupported assumptions—that (1) the lithium salt is in solid form, and (2) such solid lithium salt is added to or mixed in the solvent mixture to obtain a 1.0 mol/L concentration as a concentration of the electrolyte solution before adding the additive combination—necessarily contradict the literal text set forth in Zeng.

107. *First*, the commercial distribution of premixed “battery grade” 1.0 M LiPF_6 solution for use in batteries was well known at the time of the alleged invention of Zeng. *See, e.g.*, Ex. 2017 (“Lithium hexafluorophosphate solution in ethylene carbonate-d4 (99 atom % D) and ethyl-d5 methyl-d3 carbonate (98 atom % D), 1.0 M LiPF_6 in EC-d4/EMC-d8=3:7 (v/v), battery grade” Sigma-Aldrich Safety Data Sheet dated July 11, 2016), Ex. 2018 (“Lithium Hexafluorophosphate in EC/EMC 3:7” Safety Data Sheet dated September 2018), Ex. 2019 (“Lithium hexafluorophosphate solution - in ethylene carbonate and diethyl carbonate, 1.0M LiPF_6 in EC/DEC=50/50 (v/v), battery grade” Sigma-Aldrich Production Specification), Ex. 2020 (“Lithium hexafluorophosphate solution - in diethyl carbonate, 1.0M LiPF_6 in DEC, battery grade” Sigma-Aldrich Production Specification), Ex. 2021 (“Lithium hexafluorophosphate solution - in ethylene carbonate and dimethyl carbonate, 1.0M LiPF_6 in EC/DMC=50/50 (v/v), battery

grade” Sigma-Aldrich Production Specification). Indeed, even Dr. Lucht admits that “LiPF₆ is commercially available premixed in different solvents to different concentrations.” Ex. 1003 ¶ 66, fn. 6. Accordingly, adding the electrolyte salt LiPF₆ in the form of a salt solution having 1.0 mol/L concentration to the solvent mixture would be well known to the POSITA experimenting with different electrolyte additives and was a known and acceptable way to manufacture an electrolyte mixture.

108. *Second*, Dr. Lucht’s reliance on the language of example preparations of various electrolyte solutions set forth in three U.S. patent publications is misplaced and actually reinforces the clear meaning of the language set forth in Zeng that the LiPF₆ is added to the solvent mixture *as a salt solution having a certain concentration*. Dr. Lucht asserts that because “Zeng already discloses an EC:PC:DEC:DB:EP:PP solvent mixture for its electrolytes[, i]n such cases, it is standard practice to mix LiPF₆ in the specified solvent mixture to a target concentration—usually around 1 mol/L—not add LiPF₆, premixed in some second solvent mixture, to the first solvent mixture.” Ex. 1003 ¶ 66, fn. 6 (citing Ex. 1023 ¶¶ [0237], [0245], [0255]; Ex. 1024 ¶ [0048]; Ex. 1025 ¶ [0090]). The cited portions of Exhibit 1023, however, simply identify sample language that Zeng could have used instead if the inventors had actually intended for lithium salt to be added to a

solvent mixture to obtain a specified or target electrolyte solution concentration before the addition of the additives. Ex. 1023 ¶ [0237] (“to form a non-aqueous solvent, *into which was dissolved LiPF₆, so as to be 1.2 M*”) (emphasis added). Similarly, the paragraph in Exhibit 1024 on which Dr. Lucht relies actually identifies sample language that Zeng could have used had the inventors intended for lithium salt to be dissolved in a prepared solvent to obtain an electrolyte solution. Ex. 1024 ¶ 48 (“stir and mix homogeneously organic solvents according to certain ratios to *obtain a solvent for electrolyte solutions. Slowly add a lithium salt, and when the lithium salt is dissolved*, add additives, and stir homogeneously until there is no precipitate, suspended matter or stratification. Continue to stir for 1 hour and obtain the electrolyte solutions. The *obtained electrolyte solutions* are identified with electrolyte solutions numbers L1 to L18 depending on types and mixing ratios of organic solvents, *types of the lithium salt and concentrations thereof in the electrolyte solutions*, and types of additives and concentrations thereof in the electrolyte solutions.”) (emphases added). Moreover, Exhibit 1025 on which Dr. Lucht relies, is simply another example like Zeng wherein a 1.0 M LiPF₆ salt solution is added to the prepared organic solvent mixture. Ex. 1025 ¶ [0090]. For example, Paragraph [0090] sets forth Example 1 wherein “[a]n electrolyte was prepared by mixing ethylene carbonate and ethyl methyl carbonate (3:7 volume ratio) to prepare

a non-aqueous organic solvent and ***dissolving 1.0 M LiPF₆, hexane tricyanide (1,3,6 or 1,2,6-Hexanetricarbonitrile) (HTCN), and γ -butyrolactone (GBL) thereto.***

Herein, the hexane tricyanide and the γ -butyrolactone were used respectively in an amount of 2 wt % and 1.5 wt % based on 100 wt % of the non-aqueous organic solvent.” *Id.* (emphasis added). Similarly, Paragraph [0100] sets forth the preparation of Comparative Example 1 wherein “[a]n electrolyte was prepared by mixing ethylene carbonate and ethyl methyl carbonate (3:7 volume ratio) to prepare a non-aqueous organic solvent and ***adding 1.0 M LiPF₆ thereto.***” *Id.* ¶ [0100].

109. Indeed, it is my opinion that the applicant and inventors of Zeng knew what language to use to indicate to a POSITA that lithium salt is added, in solid form, to a solvent mixture to obtain a target concentration of the salt in the solvent mixture, but chose not to. *See e.g.*, Ex. 2022, claim 1 (“[a] non-aqueous electrolyte, comprising an organic solvent, a conductive lithium salt and an additive....”), claim 4 (“wherein the concentration of the conductive lithium salt in the organic solvent is between 0.8-1.5 mol/L....”), claim 9 (“(1) mixing the organic solvents in proportion...; (2) dissolving the conductive lithium salt in the organic solvents at room temperature, and stirring uniformly”), ¶¶ [0013] (“The concentration of the conductive lithium salt in the organic solvent is between 0.8 and 1.5 mol/L....”), [0019]-[0020] (“(1) Mix the organic solvents in the required proportions...; (2) At

room temperature, dissolve the conductive lithium salt in the organic solvents, and stir uniformly”), [0030] (“The conductive lithium salt LiPF_6 has a concentration of 1.0 mol/L in the organic solvent....”). Ex. 2022 is a 2014 Chinese patent application sharing the same applicant (Dongguan City Kaixin Battery Materials Co., Ltd.) and two of the same inventors (YANG Yongjun and WAN Huaping) with Zeng. *Id.*

110. Dr. Lucht appears to assert that there is some issue with interpreting the literal wording set forth in Zeng to mean a 1.0 mol/L solution of LiPF_6 is added to the solvent mixture because such interpretation “render[s] the ultimate concentration of LiPF_6 uncertain.” Ex. 1003 ¶ 66, fn. 6. However, such concern lacks credibility because even under Petitioner and Dr. Lucht’s erroneous solid salt form/target concentration interpretation of Zeng’s disclosure, the ultimate concentration of LiPF_6 would no longer be 1.0 mol/L and would necessarily also be “uncertain” once the various additives of the additive combination are added to the alleged 1.0 mol/L solution. *See, e.g.*, Ex. 1006 ¶ [0037].

111. Dr. Lucht further asserts that “adding some premixed solution of LiPF_6 would disrupt the carefully-crafted solvent and additive weight percentages central to Zeng’s invention.” Ex. 1003 ¶ 66, fn. 6. However, in the context of Zeng, the weight percentages of the solvent components in the final electrolyte solution is irrelevant while the additive weight percentages are explicitly described as being

based on the total weight of the electrolyte solution (i.e., not affected by the form of the electrolyte salt). Zeng simply discloses preparation of an organic solvent mixture at an *initial* relative mass ratio, to which other components are added to form the electrolyte solution, such that any alleged “disrupt[ion] [to any alleged] carefully-crafted solvent...weight percentages” (Ex. 1003 ¶ 66, fn. 6) is of no matter to Zeng. *See e.g.*, Ex. 1006 ¶ [0037]; *see also, e.g.*, Ex. 1006 ¶¶ [0012]-[0016] (“15% ≤ ethylene carbonate (EC) ≤ 35%; 5% ≤ propylene carbonate (PC) ≤ 15%; 20% ≤ diethyl carbonate (DEC) ≤ 40%; 10% ≤ ethyl propionate (EP) + propyl propionate (PP) ≤ 50; 3% ≤ fluorobenzene (FB) ≤ 10%”). To a POSITA, Zeng’s express teaching that “lithium hexafluorophosphate of a concentration of 1.0 mol/L is slowly added to the mixed solution” necessarily implies the presence of a salt solution, without the need for an explicit reference to the solvents of the solution or the volume of the added LiPF_6 solution.

112. Moreover, Paragraph [0044] of Zeng further indicates that “Table 1 lists the electrolyte solution *partial* component content,” suggesting that there are other electrolyte solution components in the electrolyte solution, such as the unknown solvent components of the 1.0 mol/L LiPF_6 solution. *See* Ex. 1006 ¶ [0044].

113. Finally, there is no language or other exposition in Zeng indicating an intended final concentration of LiPF_6 in the electrolyte mixtures. Therefore, neither

Dr. Lucht nor a POSITA can discern an intention in Zeng that would be disrupted by the addition of LiPF_6 in a pre-mixed solution—which is what Zeng plainly describes—and not in a solid state.

114. Accordingly, in view of the very wording and teachings of Zeng, a POSITA skilled in the art of lithium-ion battery electrolyte preparation would not assume that the lithium salt of Zeng's embodiments is added as a solid to reach some target concentration of the electrolyte solution of 1.0 mol/L before addition of the additives, and as such, Dr. Lucht's assumption with respect to the addition of LiPF_6 in Zeng is improper and unjustified. In turn, the concentration of at least propyl propionate and the ratio of trinitrile compound to propyl propionate in the final electrolyte solutions of Embodiments 4 and 6 of Zeng cannot be determined.

115. That is, Dr. Lucht's calculations of the alleged weight percentages of propyl propionate of "less than 17.66 wt%" and "less than 17.70 wt%" in Embodiments 4 and 6 of Zeng, respectively (Ex. 1003 ¶ 73), cannot and do not account for the solvent component(s) or the amount of solvent component(s) added by the addition of the LiPF_6 salt solution to the base solvent mixtures of Zeng. As such, Dr. Lucht's calculations of the alleged ratios of trinitrile to propyl propionate (Y/Z) of ">0.057" and ">0.056" (Ex. 1003 ¶ 123) also necessarily fail as they depend

on the weight percentage of propyl propionate based on a total weight of the electrolyte solution.

116. Thus, a central assumption underlying Dr. Lucht's calculations—that the lithium salt of Zeng's Embodiments 4 and 6 is added in solid form—is, in my opinion, diametrically opposed to the actual wording and teachings of Zeng. Rather, the lithium salt of Zeng's Embodiments 4 and 6 is plainly added in solution, without identification of the solvent(s) in which the lithium salt is dissolved or how much of such salt solution is added, such that the concentration of propyl propionate in the final electrolyte solution cannot be unambiguously determined from the teachings of Zeng, by Dr. Lucht or by a POSITA. Accordingly, Dr. Lucht fails to show that Zeng discloses, teaches, or suggests at least limitation [14.7].

b. The '131 Patent's Claimed Y/Z Ranges are Critical

117. Even if one were to assume that Dr. Lucht's flawed assumptions and calculations were reasonable and justified, and that Zeng discloses a range of Y/Z values that fall within or overlap the claimed ranges of independent claim 14, it is my opinion that the '131 Patent clearly establishes that the claimed range of Y/Z values in independent claim 14 is critical to providing the advantages that the '131 Patent's invention provides, whereas Zeng does not.

118. Even if one were to adopt Dr. Lucht's unjustified assumptions and erroneous calculations, Zeng taken as a whole would disclose, at best, electrolyte solutions with trinitrile and propyl propionate ratio concentration ranges that (Dr. Lucht claims) result in Y/Z ranges that are materially **broader** than the claimed range of Y/Z values in independent claim 14. For example, the presence of propyl propionate is not even required in Zeng such that the amount of propyl propionate in an electrolyte solution of Zeng **may be zero**. See e.g., Ex. 1006 ¶ [0015] ("10% ≤ ethyl propionate (EP) + propyl propionate (PP) ≤ 50%"), ¶ [0032] ("with the aid of the property of low viscosity of carboxylic acid ester"), claim 1. For example, an electrolyte solution of Zeng may contain 10%-50% EP and **0% PP**. Applying such null propyl propionate value to some of the disclosed embodiments results in a Y/Z value of 0, which is broader than and necessarily outside of the claimed Y/Z range of about 0.01-0.3, and is materially different.

119. Dr. Lucht opines that Zeng allegedly teaches the role of the trinitrile to be "improving low-temperature performance" by having "better solubility in the electrolyte solution, without the problem of precipitation at low temperatures." Ex. 1003 ¶ 65. But the presence of a trinitrile is also not considered necessary or even required in Zeng (and, as I discussed above, a comparison of Zeng's embodiments teaches away from using a trinitrile in its electrolyte solutions) such that the amount

of trinitrile in an electrolyte solution of Zeng may also be zero. *See e.g.*, Ex. 1006 ¶¶ [0017]-[0019] (setting forth structural formula I and its various substituents that do not require a compound of structural formula I to be a trinitrile), ¶¶ [0045]-[0046] (none of Embodiments 1-3, 5, or 7-9 contain a trinitrile based on structural formula I). For example, an electrolyte solution of Zeng may contain 0% trinitrile and still have no precipitation of crystals after storage for 10 days at -30°C. Ex. 1006 ¶¶ [0045]-[0046] (e.g., Embodiments 1-3, 5, 7-9). Applying such null trinitrile value to some of the disclosed embodiments, results in a Y/Z value of 0, which is broader than and outside of the claimed Y/Z range of about 0.01-0.3, and is materially different.

120. On the other hand, the '131 Patent explains that its specific weight percentage ratio ranges, including Y/Z values of 0.01-0.3 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 4.45V and more effectively reduce DC internal resistance of the battery. Ex. 1001, 1:55-62 (“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”) (emphasis added); 28:59-64 (“***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.***”) (emphasis added).

121. Zeng never mentions such criticality of the claimed Y/Z value ranges, nor the advantages of the '131 Patent that such narrow, specific Y/Z value ranges provide (indeed, Zeng never mentions this ratio ***at all***). Indeed, Dr. Lucht never purports that the POSITA would have known of the firm protective SEI film or the other unexpected benefits discovered by the inventors of the '131 Patent. In other words, Dr. Lucht does not suggest that the POSITA would have known that the electrolyte solutions in Embodiments 4 and 6 of Zeng would have led to the benefits of the '131 Patent, because the POSITA would not have been looking for them. Rather, the POSITA would have only been looking for capacity.

122. Dr. Lucht, however, asserts that “Zeng Embodiments 4 and 6 disclose dinitrile-based electrolytes containing a trinitrile and PP—in different relative amounts” while “[t]he remaining examples lacked both a trinitrile and PP.” Ex. 1003

¶ 156 (citing Ex. 1006 ¶¶ [0045]-[0049]). It is my understanding that Dr. Lucht opines that “[g]iven that Zeng Embodiments 4 and 6 were advantageous, this would have drawn attention to the importance of Zeng’s *Y* and *Z* proportions (satisfying the claims) in improving performance of dinitrile-based electrolytes.” Ex. 1003 ¶ 156.

123. I disagree at least because each of Embodiments 1-9 reflect a capacity retention rate between 90.3-92.2% and no precipitation of crystals after low-temperature storage for 10 days, such that a POSITA would discern no substantial difference between examples that included a trinitrile and PP and examples without a trinitrile and PP. *See e.g.*, Ex. 1006 ¶¶ [0045]-[0046]. Moreover, to the extent there is any attention drawn to such a combination of trinitrile and propyl propionate, the POSITA would have been drawn to the *lack of a trinitrile compound* in at least Embodiments 2 and 5, which had ***better*** capacity retention rates than both Embodiments 4 and 6, such that the POSITA could interpret the addition of a trinitrile compound as a factor in *lowering* capacity retention rate by comparing to other embodiments. Indeed, at least inasmuch as the addition of the trinitrile compound negatively impacts the capacity retention of Embodiments 4 and 6 compared to Embodiments 2 and 5, such negative impact would not further inspire (and would in fact deter) the POSITA to consider the relation or adjustment of trinitrile compound to propyl propionate ration (*Y/Z*).

124. In summary, it is my opinion that, based on Zeng, there is no reason for a POSITA to use a trinitrile compound as a component of an improved electrolyte composition, let alone provide a POSITA with any indication that certain ratios of dinitrile, trinitrile, and propyl propionate have advantageous properties.

3. Petitioner Fails to Show that Zeng and Hirai Render Obvious the Claimed First Electrode comprising a Single-Sided Coating with an Electrode Compaction Density (D1) and the Claimed D1/D2 Ratio of Independent Claim 14

125. Independent claim 14 requires, *inter alia*, “electrodes...the electrodes comprise a first electrode and a second electrode, **wherein the first electrode comprises a first current collector and a single-sided coating**; the second electrode comprises a second current collector and a double-sided coating; and **an electrode compaction density of the first electrode comprising the single-sided coating is D1**, and, an electrode compaction density of the second electrode comprising the double-sided coating is D2, **wherein, about $0.8 \leq D1/D2 \leq$ about 1.2.**” Ex. 1001, 35:45-36:10 (emphasis added). Petitioner equates “wherein the first electrode comprises a first current collector and a single-sided coating; the second electrode comprises a second current collector and a double-sided coating” to claim element [14.5] and “an electrode compaction density of the first electrode comprising the single-sided coating is D1, and, an electrode compaction density of

the second electrode comprising the double-sided coating is D2, wherein, about $0.8 \leq D1/D2 \leq \text{about } 1.2$ ” to claim element [14.6]. Pet. at ix (“Claims Appendix”).

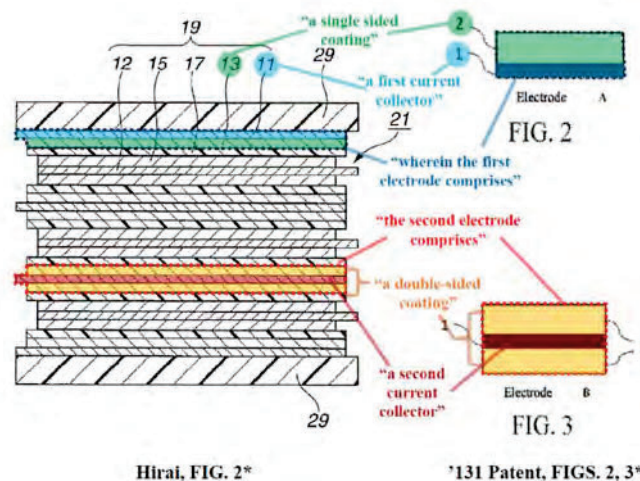
126. Petitioner and Dr. Lucht admit that Zeng “does not describe the claimed electrode configuration having *a first electrode and a second electrode, wherein the first electrode comprises a first current collector and a single-sided coating and the second electrode comprises a second current collector and a double-sided coating.*” Pet. at 26; *see also* Ex. 1003 ¶ 90. Instead, Petitioner and Dr. Lucht point to Hirai as allegedly disclosing this feature.

127. Dr. Lucht asserts that “Zeng focuses on electrolyte compositions, not electrode structures and thus does not specifically disclose the claimed electrode configuration ... however, Hirai discloses the claimed electrode configuration” and opines that “it would have been obvious to combine Zeng and Hirai, with a reasonable expectation of success to arrive at elements [14.4] and [14.5].” Ex. 1003 ¶ 90. It is my further opinion that Hirai does not and cannot cure the deficiencies of Zeng.

128. It is my understanding that Petitioner points to Hirai’s disclosure generally, and the fifth means, the sixth means, Example 5, and Example 6 of Hirai in particular, and alleges that Hirai’s structure renders obvious the claimed electrode

structures of claim 14. *See* Pet., pp. 26-43; *see also*, Ex. 1003 ¶¶ 90-122 (discussion of elements [14.4]-[14.6] with respect to Hirai).

129. I understand that Dr. Lucht opines that “either of the outermost electrodes” in FIG. 2 satisfy the claimed “first electrode” of element [14.4] comprising “a single-sided coating” of element [14.5] and “either inner electrode of the same type” satisfy the claimed “second electrode” of element [14.4] comprising “a double-sided coating” of element [14.5]. Ex. 1003 ¶¶ 91-100. To arrive at his alleged interpretation of FIG. 2, it is my understanding that Dr. Lucht depicts the electrodes as follows:



Ex. 1003 ¶ 97 (as annotated by Dr. Lucht). Thus, Dr. Lucht relies on Hirai’s FIG. 2 to assert that Hirai discloses “the first electrode comprises a first current collector and a single-sided coating” and “the second electrode comprises a second current collector and a double-sided coating,” as recited in element [14.5].

130. In asserting that Hirai discloses the claimed electrode compaction density of “about $0.8 \leq D1/D2 \leq$ about 1.2” in element [14.6], however, Dr. Lucht turns to completely different disclosures in Hirai (e.g., the fifth means corresponding to Example 5 and the sixth means corresponding to Example 6), which *only* describe electrodes with double-sided coatings. *See* Ex. 1003 ¶¶ 101-108; *see also* Ex. 1010 ¶ [0067] (describing aspects of the fifth means, referencing Example 5); ¶ [0243] (Example 5, describing that the cathode has a double-sided coating); ¶ [0245] (Example 5, describing that the anode also has a double sided coating); ¶ [0072] (describing aspects of the sixth means, referencing Example 6); ¶ [0254] (Example 6, describing that the cathode has a double-sided coating); ¶ [0245] (Example 6, describing that the anode also has a double sided coating).

131. For example, Dr. Lucht purportedly relies on the “anode electrode density” of the fifth means corresponding to Example 5 and the “cathode electrode density” of the sixth means corresponding to Example 6. Ex. 1003 ¶¶ 102-108.

132. However, none of Hirai’s examples, including Examples 5 and 6, include cathodes or anodes with single-sided coatings. *See* Ex. 1010 ¶¶ [0193] (Example 1 cathode), [0195] (Example 1 anode), [0219] (Example 2 cathode), [0212] (Example 2 anode), [0221] (Example 3 cathode), [0223] (Example 3 anode), [0232] (Example 4 cathode), [0234] (Example 4 anode), [0243] (Example 5

cathode), [0245] (Example 5 anode), [0254] (Example 6 cathode), and [0256] (Example 6 anode).

133. Realizing that Hirai is devoid of any disclosure or teaching of “an electrode compaction density of the first electrode comprising the single-sided coating is D1,” Dr. Lucht relies on impermissible hindsight to purportedly modify the double-sided coating of the outermost electrodes in Examples 5 and 6 to use single-sided coatings and to fill in the gap of the silence in the fifth means and the sixth means. That is, Dr. Lucht asserts that “[w]hile all electrodes (including the outermost electrodes) in Example 5 had a double-sided coating [], it is my opinion that a POSITA would have found it obvious to alternatively use single-sided coatings on the outermost electrodes in accordance with Hirai’s typical Figures 1-2 structure, with comparable results” and “Example 6 had double-sided coatings on all electrodes, [] but, in my opinion, it would have been obvious to alternatively implement Example 6 with single-sided coatings on the outermost electrodes according to Hirai’s typical Figures 1-2 structure.” Ex. 1003 ¶¶ 106, 108. I disagree for at least the following reasons.

134. Dr. Lucht’s assertions that “[t]he compaction density in Example 5 was intentionally controlled and a single-sided coating would have been equally controllable” and “[t]o achieve consistent energy density, a POSITA would have

controlled the single-sided coating to the same compaction density” (Ex. 1003 ¶ 106) ignores multiple factors that would necessarily be considered by a POSITA. Firstly, the “electrode densities” disclosed in Tables 9 and 11 for Examples 5 and 6 of Hirai, respectively, are only for electrodes having double-sided coatings with particular thicknesses. *See e.g.*, Ex. 1010 ¶ [0245] and Table 9 (Anodes I, J, and K each having same anode thickness of 129.6 μm but with anode electrode densities of 1.4, 1.5, and 1.6 g/cm^3 , respectively), ¶ [0254] and Table 11 (Cathodes J, K, and L each having same cathode thickness of 117 μm but with cathode electrode densities of 3.1, 3.2, and 3.3 g/cm^3 , respectively). The identified electrode densities are *average* densities for an electrode with a double-sided coating—both sides are not necessarily equally distributed. Simply removing the active layer coating from one side of a current collector, or failing to coat the second side altogether, would not result in the exact same density as the disclosed double-sided average value. Secondly, the end use of a battery requires that its constituents be designed to fit within a certain space/geometry/volume. Although removing the active layer coating from one side of a current collector will remove mass and volume from the battery, a POSITA would necessarily re-optimize, reconsider, or otherwise vary other properties throughout the battery and re-distribute the mass and volume (including the thickness and density of remaining active material coatings). Indeed, Hirai’s desire

to “make the cell volume equal” (Ex. 1010 ¶¶ [0068], [0072], [0190]) and “make the cell thickness equal as a whole” (Ex. 1010 ¶¶ [0067], [0188], [0189]) would further discourage a POSITA from using a single-sided coating for the outermost layer in Hirai’s Examples 5 and 6. That is, Hirai teaches with respect to the fifth and sixth means that “[e]ven if the amount of the cathode or anode active material to be applied is increased, it is also possible to make the cell volume equal by making the opposed electrodes in each lamination equal in energy density (thickness).” Ex. 1010 ¶¶ [0068], [0072].

135. Moreover, Hirai’s teachings regarding the electrode density value of active material double-sided layers or coatings cannot be directly used or applied as the electrode density value for a single-sided layer or coating of active material, nor would a POSITA be inspired to apply the double-sided layer data of Hirai to a single-sided system. The electrode density value is affected by a multitude of parameters such as the content of particles, particle sizes, thickness of layer, etc. Hirai does not provide any hint to a POSITA that such parameters of a double-sided layer or coating in Examples 5 and 6 could or should be adjusted to achieve the same electrode density with a single-sided layer or coating as Hirai does not even care about or provide any examples of the electrode density of a single-sided coating or layer. Indeed, in manufacturing processes where electrodes with double-sided layers and

single-sided layers are prepared, the gap between or force setting of the rollers used is usually fixed for both types of electrodes as they would be prepared in rapid sequence on the same equipment, which in turn, would lead to different electrode densities of electrodes having single-sided coatings and electrodes having double-sided coatings due to different initial total thicknesses. The engineering difficulty in properly compacting even a single layer is substantial, and would be significantly more complex when additional layers are involved. *See, e.g.*, Ex. 2041.

136. Accordingly, at least inasmuch as the fifth means, the sixth means, Example 5, and Example 6 of Hirai do not disclose an embodiment with both a first electrode comprising a single-sided coating and a second electrode comprising a double-sided coating, Hirai cannot disclose an electrode compaction density of the single-sided coating (D1) or wherein, about $0.8 \leq D1/D2 \leq 1.2$, such that Hirai does not disclose or render obvious at least elements [14.5] and [14.6].

a. The '131 Patent's Claimed D1/D2 Ranges are Critical

137. Even if Hirai were determined to disclose a range of D1/D2 values that fall within or overlap the claimed range of independent claim 14, it is my opinion that the '131 Patent clearly establishes that the claimed range of D1/D2 values in independent claim 14 is critical to providing the advantages that the '131 Patent's invention provides, whereas Hirai does not.

138. The '131 Patent explains that its specific electrode compaction ratio, including D1/D2 values of 0.8-1.2, has a synergistic effect between the combined electrolyte additives and the electrode compaction density ratio. Ex. 1001, 31:53-57 (“It can be seen that when D1/D2 is within the range of 0.8-1.2, *a better cycle performance is obtained, possibly because the combined additives facilitate the reduction of the electrode interface resistance and the reduction of the cell polarization.*”) (emphasis added).

139. Hirai never mentions anything about specific electrolyte additives or such criticality of the claimed D1/D2 value ranges, nor the advantages of the '131 Patent that such narrow, specific D1/D2 value ranges provide. Indeed, Dr. Lucht never purports that the POSITA would have known of the unexpected benefits discovered by the inventors of the '131 Patent.

4. Petitioner Fails to Show That a POSITA Would Have Combined Hirai with Zeng

140. Dr. Lucht opines that “a POSITA would have used Hirai’s battery structure—including the fifth or sixth means to control the A/C ratio based on compaction density—in Zeng’s battery, with a reasonable expectation of success.” Ex. 1003 ¶ 110. I disagree that a POSITA would be motivated to combine Hirai with Zeng for at least the reasons below.

141. Dr. Lucht asserts that “Zeng and Hirai relate to analogous art” because “Zeng seeks to improve performance of lithium-ion batteries, which have electrode assemblies, by describing advantageous electrolyte compositions” and “Hirai similarly seeks to improve the performance of lithium-ion batteries[] through electrode configurations that smooth electrode output unevenness caused by temperature differences across a laminated battery.” Ex. 1003 ¶ 110, citing Ex. 1010 ¶ [0010]. The POSITA would not be motivated to combine Hirai with Zeng at least inasmuch as Zeng is focused on a wide-temperature-range homogenous non-aqueous electrolyte solution to provide certain performance advantages for the lithium-ion battery and Hirai is focused on manipulating the anode/cathode (A/C) ratio in a laminated-structure battery to allegedly suppress output unevenness and improve durability. *See e.g.*, Ex. 1010 ¶¶ [0003]-[0010].

a. Zeng and Hirai Are Directed to Different Battery Configurations

142. Dr. Lucht further asserts that “the references provide teaching, suggestion, or motivation for a POSITA to use Hirai’s laminated battery configuration, including the fifth or sixth means to set a desired A/C ratio.” Ex. 1003 ¶ 111. In particular, Dr. Lucht asserts that “Zeng does not specify a particular physical embodiment for its batteries” and “a POSITA would have needed to choose a battery/electrode embodiment to implement Zeng’s electrolyte solutions, and Hirai

provides a suitable solution.” *Id.*, ¶ 112. I disagree at least because there is no reason a POSITA would have looked to Hirai (or had a reasonable expectation of success in combining Hirai with Zeng) for battery configuration details when Hirai does not specify anything about electrolytes, much less the relationship between electrode compaction density and an electrolyte having the same or a similar additives as Zeng. Indeed, Dr. Lucht tries to equate Hirai’s focus on “large-size batteries like on-vehicle batteries” with Zeng’s lithium-ion batteries. *Id.*, ¶ 112 (Dr. Lucht opining that “a POSITA would have looked to Hirai’s laminated battery structure in particular because Zeng identifies large-battery applications for its electrolytes, such as in the ‘... energy storage, power, and military aerospace fields.’”) (citing Ex. 1006 ¶ [0002]). However, Zeng doesn’t say anything about “large-size”, “on-vehicle batteries”, or “laminated-structures,” much less anything that would have prompted a POSITA to look to Hirai for modifications to any such battery configurations. Indeed, Dr. Lucht’s assertion that “Zeng identifies large-battery applications for its electrolytes” ignores the fact that Zeng is generally describing lithium-ion batteries in its “Background Art” section, not a specific-use case for its batteries. Ex. 1006 ¶¶ [0002]-[0008] (titled “Background Art”). Moreover, Zeng lists at least the additional field of “digital”, as well as “consumer terminals” (*id.*, ¶¶ [0002]-[0003]) and Hirai specifically distinguishes such “consumer terminals” from its “large-size,

laminated-structure batteries like [] on-vehicle batteries.” Ex. 1010 ¶ [0006] (“in contrast with small-size batteries of a winding structure generally used for cellular phones and mobile personal computers.”).

143. Dr. Lucht further opines that “Hirai controls A/C ratio to smoothen the power output of the individual electrodes in the stack despite the temperature difference between the inner and outermost electrodes in the laminated battery” and “[t]his advantage would have further enticed a POSITA to use Hirai’s structure for Zeng’s battery.” Ex. 1003 ¶ 114 (citing Ex. 1010 ¶¶ [0010], [0012], [0019], [0029]-[0033], [0045]-[0076]). I disagree at least because the problem Zeng is trying to solve, and the mechanism with which Zeng is trying to solve it, are unrelated to smoothing power output in a laminated battery. That is, Zeng seeks to improve electrode plate wettability and interfacial compatibility through a wide-temperature-range homogeneous non-aqueous electrolyte solution. Nothing in Zeng would instigate, prompt, or motivate the POSITA to consider Hirai’s alleged technique for “suppressing output unevenness” to smooth power output in a laminated battery.

b. Hirai’s Central Hypothesis is Clearly Erroneous and Not Enabled

144. I also disagree at least because Hirai’s central hypothesis is flawed and clearly erroneous. To understand the problem that Hirai purports to solve, some background is necessary. It is well known in the lithium-ion battery field that the

A/C ratio, which is the ratio of lithium storage capacity of the anode to that of its adjacent cathode, should never be below 1. If the A/C ratio is below 1, there is a tendency for lithium ions to plate or precipitate as lithium metal on the surface of the anode during cell charging, which is considered deleterious to battery longevity and safety. Consequently, cells are designed universally to have an A/C ratio slightly greater than 1. Even with this fact in mind, manufacturers know that at temperatures well below room temperature, graphite anodes can become sluggish in how rapidly they can accept lithium. Manufacturers further know that if fast charging is attempted at this low temperature, the anode may fail to accept the lithium being provided by the cathode, causing deleterious lithium plating to yet occur even though A/C is greater than 1. This is remedied by having battery management systems (whether in a phone or an electric vehicle) that do not permit so-called “fast charging” while the battery is at low temperature. Manufacturers may further remedy this problem by electrolyte additives that reduce the tendency for lithium precipitation to occur.

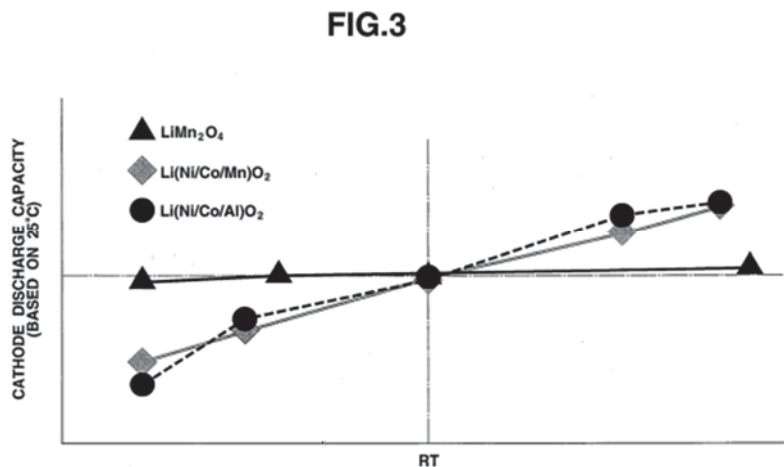
145. Hirai’s central hypothesis is that the A/C ratio becomes a function of position inside the cell due to temperature differences that develop during operation, leading to “output unevenness of the single battery layers (single cells) of the center portion and the end portion.” Ex. 1010 ¶ [0030]. Therefore, according to Hirai, a

battery designer can and should reduce the impact of this by designing a compensating baseline A/C ratio into the cell. Specifically, Hirai states that the A/C ratio gets smaller with increasing temperature so that when the center of the cell gets hotter than the periphery, the A/C ratio in the center becomes problematic. *See id.*, ¶ [0007] (“the temperature difference between the center portion and the end portion in the direction of lamination becomes even larger, thereby causing an output unevenness between a single battery layer (single cell) at the center portion (inner side) and that at the end portion (outer side) in the direction of lamination. A mechanism to generate such output unevenness is considered as follows. As the temperature is higher, the charge and discharge capacity on the cathode side increases (see FIG. 3). With this, the capacity ratio (A/C ratio) of the anode capacity (Li discharge) to the cathode capacity (Li acceptance) decreases.”).

146. However, Hirai’s alleged teachings are logically and scientifically flawed for multiple reasons. First, Hirai fails to establish that the A/C ratio in fact becomes a noticeable function of position. Second, even if this were true, it is at best a *temporary* phenomenon that depends on a cell being charged or discharged very rapidly (thus generating large amounts of heat), and so would not be true under most, or even necessarily any, operating conditions. For example, if one compensates for alleged “output unevenness” at an elevated temperature as suggested by Hirai

(Ex. 1010 ¶ [0030]), an *opposite* output unevenness is in fact created when the center of the cell is *not* at an elevated temperature. Third, even if the preceding conditions were true, it would only be a problem if the cell were being charged and remained at temperatures well below room temperature, i.e. when the graphite anode has sluggish kinetics leading to lithium precipitation. It is fundamentally flawed to imply, as Hirai does, that the center of the cell will be at elevated temperature and yet still cold enough for lithium plating to be a problem.

147. Moreover, Hirai's teaching, based on FIG. 3, that the A/C ratio becomes problematically small in the center of the cell is scientifically lacking. FIG.3 (reproduced below) is incomplete and does not properly disclose what Hirai purports to disclose, namely, that as temperature is increased, the A/C ratio of the electrodes decreases by a consequential amount (*see e.g.*, Ex.1010 ¶¶ [0007], [0107]-[0109]):



Ex. 1010 FIG. 3.

148. First, both axes of FIG. 3 of Hirai lack numbers such that a POSITA would not actually know how much temperature was changed (horizontal axis) or how much discharge capacity of cathodes changed (vertical axis). Instead, all that a POSITA learns is a qualitative trend of unknown magnitude. Second, FIG. 3 of Hirai does not contain any capacity vs. temperature data for anode materials, such as graphite, that a POSITA could compare to the behavior of the cathode active materials and thereby determine A/C ratio upon change in temperature. Third, Hirai only provides data for LMO, NMC, and NCA cathode active materials, and so this purported phenomenon is not established as universal to all cathodes a designer might want to use, let alone an LCO cathode active material as is used in Zeng. Fourth, there is no information that would allow a POSITA to assess the temperature in the center of the cell vs. the edges during high-rate operation. For instance, a rate or current at which the charging or discharging is performed, for how many cycles, and what external cooling means were employed. The reason this is important is that the heating effect in the center is highly sensitive to a range of conditions. Accordingly, A POSITA interpreting FIG. 3 or Para. [0007] of Hirai would not be able to discern or learn to what degree the A/C ratio actually changes during operation and therefore how one could compensate thereby.

149. Hirai's embodiments also are lacking in scientific validity due to an attempt to discern effects of A/C ratios only at high temperatures. For example, Paragraph [0283] of Hirai states that testing for all cells was performed by cycling at 50 °C and a 1C rate. Ex. 1010 ¶ [0283] ("By using the laminated-structure battery prepared by the above procedure under a storage at 50° C., a cycle test (durability test) was conducted. As the cycle condition, it was conducted 500 cycles between 4.2 V to 3.0 V at 1 C rate."). First, this is a high temperature to be performing cycling tests which can lead to significant changes in outcomes. An elevated temperature is associated with accelerated testing, in which the temperature is used to make the cells fail more rapidly to test the effect of some variable during a timescale that is convenient for the tester. A POSITA would recognize that, with accelerated testing, different failure modes are affected by temperature to different degrees. When temperature is changed, the different failure modes become more or less significant compared to each other, as each has a unique dependence on temperature. *See, e.g.*, Ex. 2030. Of particular note for Hirai's tests at 50 °C, A/C ratios would not be expected to be an impactful factor due to little likelihood of lithium metal plating on the anode.

150. Second, paragraph [0283] of Hirai states that a rate of 1C was used by Hirai. Ex. 1010 ¶ [0283] This means that tests were performed at a nominal rate that

would lead to 1 hour charges and 1 hour discharges. This is not a particularly high rate and is extremely unlikely to lead to a large temperature difference in Hirai's cells between the center and the edges, which is necessary for Hirai's central hypothesis to be tested.

151. Third, Hirai never establishes its central hypothesis by direct experiments, namely by performing proper measurements of A/C ratio either before or after cell assembly and cycle testing are performed. In order to measure A/C ratio—as proposed in Hirai paragraphs [0205] and [0291]-[0292] and purported in Tables 2, 4, 6, 8, 10, 12, 15, and 16—anode capacities must be determined independently from cathode capacities. This cannot reliably be done for the *full* cells of Examples 1-6 and Comparative Examples 1-2; measurements are instead purportedly done by placing each anode and cathode (either pristinely made or harvested from a cycled cell) into a separate *half* cell where lithium metal is the counterelectrode and acts as an inexhaustible supply of lithium. These test cells must be cycled across an appropriate potential range in order to determine anode/cathode capacity. However, Hirai reports a scientifically flawed method in which the anode half cells are cycled from 3.0V to 4.25V. Ex. 1010 ¶¶ [0205], [0291]-[0292]. A POSITA would recognize that these voltage limits are much higher than where graphite anodes operate vs. lithium metal and therefore would fail to determine

anode capacity (in contrast, voltages in the range 0.05V to 1.0V, for instance, would have been appropriate). This scientific lapse suggests to the POSITA that Hirai is not correctly or accurately confirming intended A/C ratios. Such experimental confirmation is necessary because calculated theoretical capacities, for instance based on the masses of raw active materials included in the coatings, are rarely realized in practice. Instead, the only testing performed by Hirai on the prepared examples and comparative examples and thus, the only properties that Hirai measures for the prepared laminated-structure batteries, are overall capacity loss and “energy density.” Ex. 1010 ¶¶ [0284]-[0288], Table 17. Hirai does not actually report data from pristine electrodes or from post-mortem testing of the prepared examples and comparative examples that would confirm Hirai’s central hypothesis regarding the benefit of manipulating A/C ratios.

152. All of this means that a POSITA would not find Hirai instructive to solving the purported A/C ratio problem or otherwise “suppressing output unevenness” as alleged by Dr. Lucht. Ex. 1003 ¶¶ 114-116.

153. Moreover, a POSITA would not have been “motivated to use Hirai’s fifth (Example 5) or sixth (Example 6) technique to control the A/C ratio and stabilize power output—both of which involve adjusting the compaction densities of the active materials of the individual electrodes in the laminated battery—in

Zeng's battery," nor would a POSITA "have seen the fifth and sixth means—which do so through intentionally setting compaction densities of the electrodes in the lamination—as superior," as alleged by Dr. Lucht. Ex. 1003 ¶¶ 115-116.

154. The sixth means of Hirai purports to "mak[e] the center portion higher than the end portion in A/C ratio," by making "the center portion [] to be lower than the end portion in the direction of lamination in terms of the cathode electrode density of each single battery layer." Ex. 1010 ¶ [0072]. However, the corresponding Example 6 upon which Dr. Lucht relies does not set forth a center portion having a lower cathode electrode density compared to the end portion. That is, Table 11 of Hirai lists the "cathode electrode density (g/cm³)" of Cathodes J, K, and L as 3.1, 3.2, and 3.3, respectively:

TABLE 11			
Mass per unit area of Cathodes J to L (the amount of cathode active material per unit area of both surfaces of Al foil) and cathode electrode density (mass of cathode active material/volume of cathode active material in cathode active material layer)			
	Cathode J	Cathode K	Cathode L
Mass per unit area (mg/cm ²)	15	15.5	16
Cathode electrode density (g/cm ³)	3.1	3.2	3.3

and Table 12 of Hirai lists the lamination positions of the cathodes from the bottom up of the laminated structure battery as Cathode J, Cathode K, Cathode L, Cathode K, and Cathode J:

TABLE 12

Lamination number	1	2	3	4	5
Cathode	J	K	L	K	J
Anode	L	L	L	L	L
A/C ratio	1.1	1.12	1.15	1.12	1.1

Accordingly, Example 6 sets forth an example with a center portion having a *higher* cathode electrode density (Cathode L at 3.3 g/cm³) than the end portion (Cathode J at 3.1 g/cm³), which is directly opposite of the sixth means and would lead to A/C ratio actually being lowest in the center (i.e. Lamination number 3) and highest on the edges (i.e. Lamination numbers 1 and 5).

**c. Dr. Lucht's Assertions of "Obvious to Try"
Necessarily Fail**

155. For several reasons, I disagree with Dr. Lucht's opinions that "a POSITA would have found it 'obvious to try' the fifth and sixth means of Hirai for Zeng's battery structure" and that "Examples 5 and 6 would have worked predictably as the structure for Zeng's battery because Hirai tested them with good results." Ex. 1003 ¶¶ 117-118. For one, simply trying to combine Zeng with Hirai would not lead a POSITA to combine the references in the manner proposed by Dr. Lucht, as discussed herein.

156. But I also disagree with the premise that the combination would be obvious to try in the first place, as there are numerous possible battery configurations beyond Hirai's complex arrangement and the requirements in the battery art are so

challenging and varied from application to application, the set of possible battery configurations and combinations is effectively infinite, and the outcomes unpredictable. Especially considering thousands upon thousands of scientific references that disclose aspects of or improvements to lithium-ion battery technologies, there is no design principle that makes Zeng and Hirai complementary or apropos to each other; only Dr. Lucht's inappropriate hindsight would recommend them together among the vast field of lithium-ion battery teachings.

157. Nor would a few overlapping electrolyte components between Zeng and Hirai lead a POSITA to “expect Hirai’s fifth and sixth structures to work predictably as the battery structure for Zeng’s electrolyte” as asserted by Dr. Lucht. Ex. 1003 ¶ 118. An electrolyte optimized for use with the LCO cathode active materials of Zeng’s Embodiments 4 and 6 would not necessarily be optimized for use with the NCA cathode active materials of Examples 5 and 6 of Hirai. Indeed, the high operating temperatures of Hirai leave the teachings of Hirai to be irrelevant and nontransferable to other systems, like Zeng, that have lower operating temperatures. For example, Hirai’s examples are cycle-tested at 50°C and Zeng’s examples are cycle tested at ambient temperature and tested for low temperature storage. *Compare* Ex. 1006 ¶ [0041] (25°C) and ¶ [0038] (-30°C) *with* Ex. 1010 ¶ [0283] (50°C).

d. A POSITA Would Not Modify Hirai as Opined by Dr. Lucht

158. Dr. Lucht also opines that “Hirai’s acknowledgement that large, laminated batteries retain too much heat would have motivated a POSITA to use Hirai’s Figures 2 and 3 structure—i.e., where the outermost electrodes, adjacent cladding 29, having a single-sided active layer coating” (Ex. 1003 ¶ 119 (citing Ex. 1010 ¶¶ [0006]-[0010], [0024],-[0025], FIGS. 2, 3) and further asserts that “a POSITA considering Hirai would have looked for ways to reduce heat insulation of the battery and meet Hirai’s goal of consistent power output through a balanced strategy—partly addressing both the root cause and the symptom.” Ex. 1003 ¶ 119. For several reasons, I disagree that a POSITA would have modified the fifth means, sixth means, Example 5, or Example 6 of Hirai in order to implement a battery structure having a single-sided coating in the outermost electrodes, as asserted by Dr. Lucht.

159. First, as conceded by Dr. Lucht, Examples 5 and 6 *only* use electrodes with double-sided coatings. *See e.g.*, Ex. 1010 ¶¶ [0242]-[0245] (describing Example 5 as “a coating [of a cathode slurry] conducted on both surfaces of an aluminum foil as the cathode collector...” and “a coating [of an anode slurry] conducted on both surfaces of a copper foil as the anode collector...”), [0253]-[0256] (describing Example 6 as “a coating [of a cathode slurry] conducted on both

surfaces of an aluminum foil as the cathode collector...” and “a coating [of an anode slurry] conducted on both surfaces of a copper foil as the anode collector...”).

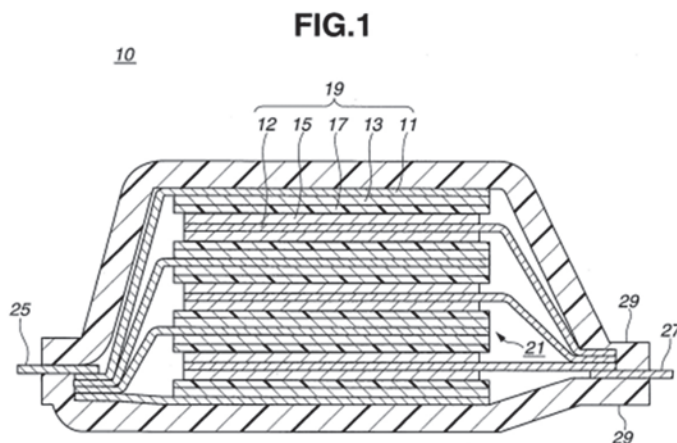
160. Second, manufacturing of cells with both single-sided and double-sided coatings is not a trivial undertaking and is actually quite difficult. The effort to run a separate manufacturing process for the interior and edge layers would entail considerable cost. Indeed, Hirai even alludes to such manufacturing difficulty. *See* Ex. 1010 ¶ [0025]. For instance, Hirai explains that, although FIGS. 1 and 2 illustrate “cathode active material layers 13 [] arranged on only one surfaces of the outermost cathode collectors positioned at both outermost layers of power generation element 21, it is optional to form the active material layers on both surfaces,” that is, “it is optional to use a collector formed on [] both surfaces with active material layers as it is as a collector of the outermost layer, **not making a collector, which is formed on its only one surface with an active material layer, only for the outermost layer.**”). *Id.* (emphasis added). In other words, Hirai describes that FIGS. 1 and 2 illustrate an embodiment in which the outermost cathodes are formed with active material only on one side (while all other cathodes in the battery have active material formed on both sides), but in an alternative embodiment, the outermost cathodes is formed with active material on both sides so that all cathodes in the battery are formed with active material on both sides and thus the battery manufacturer need not

implement a separate manufacturing process “only for the outermost layer,” which a POSITA would understand to increase costs by a considerable amount. *See id.* The fact that none of Hirai’s examples include single-sided electrodes (*see* Ex. 1010 ¶¶ [0192]-[0256]) suggests that the embodiment depicted in FIG. 1 and 2 is not preferred, and that the alternative embodiment with all double-sided electrodes is instead the preferred embodiment.

161. Moreover, a POSITA would not be motivated to try a process that leads to such manufacturing difficulties unless the combination were solving a dire and specific need, not some generic effort to mildly improve performance of cells in an ill-defined and nonspecific way, as Dr. Lucht maintains. As such, Dr. Lucht’s assertion that “[a]s added benefits, fewer layers may reduce manufacturing cost” (Ex. 1003 ¶ 120) also rings false.

162. Third, Dr. Lucht’s principle argument that a POSITA would be motivated to make such alteration to Hirai’s examples (i.e., to convert the double-sided outer layers in Hirai’s examples to single-sided outer layers) to increase the heat transfer from the cell also necessarily fails. Firstly, the principal mode of heat transfer from the interior of a cell to the exterior is laterally through the current collector foils, universally made of highly conductive aluminum (in the case of cathodes) and copper (in the case of anodes) metals. As shown in FIG. 1 of Hirai,

the current collectors (cathode collector 11, anode collector 12) protrude from each layer in the lateral directions (left and right in the orientation of the figure) where they are gathered together into a single current path (cathode collecting tab 25, anode collecting tab 27):



This electrical current path (not coincidentally) is also the principal path for heat transfer. Therefore, Dr. Lucht's proposed change to the coatings on the outermost current collectors will not have a significant effect on heat transfer. Secondly, given that Hirai is purportedly motivated to solve the temperature-unevenness problem, Hirai itself would be motivated to improve heat transfer from the cell center to the periphery without any additional external motivations or teachings by Dr. Lucht, and yet did not make the change suggested by Dr. Lucht. Indeed, Dr. Lucht's assertions that "a POSITA could meet Hirai's goal of consistent power output with less manipulation of the A/C ratio at the battery interior" which "in turn, would

potentially allow simplifying the construction of the various inner electrodes, further reducing cost” is contrary to his assertion that a POSITA would even be led to Hirai in the first place.

e. Dr. Lucht Fails to Establish a Reasonable Expectation of Success

163. Dr. Lucht further opines that “a POSITA would have had a reasonable expectation of success using Hirai’s configuration for Zeng’s battery”, asserting that “Zeng does not require any specific battery structure beyond identifying potential large-battery applications in the “energy storage, power, and military aerospace fields” and “[t]he POSITA would have reasonably expected Hirai’s battery structure to be appropriate for such ‘large-size batteries like on-vehicle batteries in particular.’” Ex. 1003 ¶ 121 (citing Ex. 1006 ¶ [0002] and Ex. 1010 ¶ [0021]). I disagree at least because, as discussed above in Paragraph 142, Zeng is generally describing lithium-ion batteries in its “Background Art” section when identifying “the digital, energy storage, power, and military aerospace fields”, not a specific-use case for its batteries. Ex. 1006 ¶¶ [0002]-[0008] (titled “Background Art”). Moreover, Zeng identifies “consumer terminals” (*id.*, ¶ [0003]) and Hirai specifically distinguishes such “consumer terminals” from its “large-size, laminated-structure batteries like [] on-vehicle batteries.” Ex. 1010 ¶ [0006] (“in contrast with small-size batteries of a winding structure generally used for cellular phones and

mobile personal computers.”). In addition, the requirements in the battery art are so challenging and varied from application to application, and the outcomes are unpredictable. Because Hirai does not say anything specific about electrolytes, much less the relationship between electrode compaction density and an electrolyte having the same or a similar additives as Zeng, a POSITA would not be able to predict, with any level of real certainty, a result from “using Hirai’s configuration for Zeng’s battery,” as alleged by Dr. Lucht. *See, e.g.*, Ex. 1003 ¶ 121.

164. I provide an analogy to further explain the above points. If there were multiple parties all working to improve automobile performance, and one party disclosed an improved gasoline fuel additive and another party disclosed an improved radiator for heat dissipation, a POSITA would not find it obvious to combine the two disclosures. Even though the disclosures nominally deal with “improving cars,” they teach remedies to entirely different problems in a complicated engineering system. Such is the case that a POSITA would view the disclosures of Zeng and Hirai: they may generically deal with improving battery performance, but on closer inspection they are attempting to solve completely independent problems with completely independent methods. Moreover, Zeng seeks to increase battery performance through a wide-temperature-range homogeneous non-aqueous electrolyte solution and does not contemplate heat generation impacts

on battery characteristics. In other words, the solution discussed in Zeng is chemical in nature, while the solution discussed in Hirai is mechanical in nature.

165. Additionally, Dr. Lucht's assertions that "Hirai's detailed description and figures showing the construction of battery 10," "Hirai describes in detail how to configure the active layer coatings for the fifth and sixth means and to make the remaining parts of the battery," and "Hirai's exemplary electrolyte shares common components with Zeng Embodiments 4 and 6" somehow would have provided the POSITA with a reasonable expectation of success "in combining Zeng and Hirai" is also unconvincing. Ex. 1003 ¶ 122 (citing Ex. 1010 ¶¶ [0028], [0066]-[0190], [0242]-[0263], FIGS. 2, 3 and Ex. 1006 ¶¶ [0024], [0037], [0044]). First, as described above, there is no reason a POSITA would have looked to Hirai (or had a reasonable expectation of success in combining Hirai with Zeng) for battery configuration details when Hirai does not say anything about electrolytes, much less the relationship between electrode compaction density and an electrolyte having the same or a similar additives as Zeng. Second, although Hirai's exemplary liquid electrolytes include two carbonate electrolyte components (EC, DEC) and a lithium salt, Hirai's examples are silent with respect to any other solvent components, such as ethyl propionate or propyl propionate, or additives. Indeed, Hirai only uses a regular or typical electrolyte of 1M LiPF₆ in EC:DEC = 5:5 (molar ratio), yet

nowhere does Hirai mention additives, such as dinitriles or trinitriles, while all of Zeng's electrolytes contain additives. The electrolyte systems vary vastly such that a POSITA would not be motivated to combine such references. In addition, Hirai applies an NCA cathode active material in each of its examples and comparative examples, which differs from the LCO cathode active material used in Zeng's examples. A POSITA would not have "reasonably expected to succeed in combining Zeng and Hirai" simply based on a few overlapping carbonate solvent components as alleged by Dr. Lucht (Ex. 1003 ¶ 122) as an electrolyte optimized for use with LCO cathode active material and Zeng's temperature and other intended operating conditions would not necessarily be optimized for use with NCA and Hirai's temperature and other intended operating conditions.

166. Thus, I disagree with Dr. Lucht's suggestion that a POSITA reading the Zeng and Hirai references would have been motivated to reach the same solution that the inventors of the '131 Patent arrived at, which disclosed an unexpected beneficial connection between electrolyte formulation and electrode compaction density.

5. Claims 15-17 Are Not Unpatentable

167. Claims 15-17 are not unpatentable for the same reasons as discussed above with respect to independent claim 14. I reserve the right to address claims 15-17 individually if this proceeding is instituted.

B. Ground 1B: Zeng, Hirai, and Matsuoka Do Not Render Obvious Claims 14-17

168. It is my understanding that in Ground 1B, Petitioner asserts and Dr. Lucht opines that Zeng, Hirai, and Matsuoka render obvious claims 14-17 of the '131 Patent. Pet., pp. 51-57; Ex. 1003 ¶¶ 140-153. In particular, Dr. Lucht relies on Matsuoka for element [14.7] and opines that “any potential ambiguity can be dispelled by Matsuoka, [] which explicitly discloses an appropriate amount of PP (Z).” *Id.* ¶ 141. I disagree for at least the following reasons.

169. For the same reasons noted above with respect to Zeng and Hirai in Ground 1A, it is my opinion that a POSITA would not have selected or implemented Embodiments 4 and/or 6 of Zeng, that the disclosure of Zeng does not provide sufficient detail that would allow the POSITA to determine that Zeng discloses the weight percentages of propyl propionate (Z), and in turn, the claimed ratio of trinitrile to propyl propionate (Y/Z) of independent claim 14, and Zeng says nothing about the critical claimed ratio of trinitrile to propyl propionate (Y/Z) of independent

claim 14. It is my further opinion that Matsuoka does not cure these failures of Zeng (or any of the failures of Hirai).

170. In addition, nothing in Zeng would instigate, prompt, or motivate the POSITA to “consider Matsuoka’s teachings about appropriate amounts of PP to include in Zeng’s electrolytes” as alleged by Dr. Lucht. Ex. 1003 ¶ 148. Petitioner and Dr. Lucht are simply contriving some purpose in hindsight for why a POSITA would look beyond Zeng when no such reason exists. Contrary to Dr. Lucht’s assertion, the POSITA would not be prompted to look beyond Zeng, let alone “consider Matsuoka’s [alleged] teachings about appropriate amounts of PP to include in Zeng’s electrolytes” because Zeng already provides an “appropriate amount” of propyl propionate to include in relative mass ratio in the base solvent mixture—the weight percentage of propyl propionate based on a total weight of the electrolyte is simply not important to Zeng.

1. Petitioner Fails to Show that a POSITA would have Selected Propyl Propionate from Matsuoka’s Teachings of Numerous “Non-Nitrile Additives”

171. Matsuoka proposes the addition of “non-nitrile additives” to a non-aqueous electrolyte solution, the electrolyte solution containing acetonitrile and a lithium salt. Ex. 1007 ¶ [0033]. According to Matsuoka, suitable non-nitrile additives include compounds having a Lowest Unoccupied Molecular Orbital

(LUMO) energy and a Highest Occupied Molecular Orbital (HOMO) energy falling in specified ranges. Ex. 1007 ¶¶ [0036], [0038]-[0040]. Paragraphs [0038]-[0040] of Matsuoka list numerous compounds that have such advantageous LUMO and/or HOMO energies in the specified ranges. *Id.*

172. Dr. Lucht asserts that “Matsuoka identifies benefits of PP as an electrolyte additive.” Ex. 1003 ¶ 143. Although two PP isomers (n-propyl propionate and isopropyl propionate) are included in Matsuoka’s large list of example non-nitrile additives, neither compound is given special significance in Matsuoka nor is the effect of such propyl propionate compounds clearly stated. *See e.g.*, Ex. 1007 ¶¶ [0038] (“n-propyl propionate (0.49 eV),...isopropyl propionate (0.49 eV)”, [0040] (“n-propyl propionate (-7.10 eV),...isopropyl propionate (-7.07 eV)”). Indeed, each propyl propionate compound is merely listed as one of numerous possible compounds, but neither are tested for actual functionality. *See e.g., id.* (listing the propyl propionate compounds among 76 possible LUMO compounds reiterating that Dr. Lucht’s proposed selection is extremely broad, not the optimal choice, and would not necessarily be selected among numerous substances). Significantly, Table 2 of Matsuoka lists 20 additives (A1 to A20) used in the Examples and Comparative Examples and neither propyl propionate compound is identified. Ex. 1007 ¶ [0108], Table 2.

173. Moreover, Dr. Lucht's assertion that the "PP isomers having LUMO [] and HOMO [] energies falling in or near most-preferred ranges" (Ex. 1003 ¶ 143) is of no consequence as nearly all of the additives in the LUMO list fall within the "most-preferred" LUMO range (-2.00 to 0.60 eV) and a majority of the additives in the HOMO list fall within or near the "most-preferred" HOMO range (-8.50 to -7.25 eV). Ex. 1007 ¶¶ [0036], [0038]-[0040]. Indeed, 69 of the 76 non-nitrile additives have LUMO energies falling within the "most-preferred range" for LUMO energies and a majority of the non-nitrile additives have HOMO energies, like the PP isomers, fall "near [the] most-preferred" HOMO range. *Id.*

174. Thus, given Matsuoka's lack of disclosure as to any particular significance of propyl propionate, it is my opinion that a POSITA would have no reason to single out propyl propionate from Matsuoka's teachings of numerous "non-nitrile additives."

2. Petitioner Fails to Show That Zeng, Hirai, and Matsuoka Render Obvious the Claimed "A Weight Percentage of the Propyl Propionate" and, in turn, the Claimed Y/Z Range in Independent Claim 14

175. Element [14.7] requires "wherein based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z; wherein, about $0.01 \leq (Y/Z) \leq \text{about } 0.3$." Ex. 1001, 33:39-43, 36:10-13; Pet., ix ("Claims Appendix). For at least the following reasons, it is my opinion that Petitioner and Dr. Lucht fail

to show that Zeng, Hirai, and Matsuoka render obvious the claimed “weight percentage of the propyl propionate” (Z) “based on the total weight of the electrolyte” and in turn, the claimed Y/Z range of element [14.7].

176. According to Matsuoka, “[t]he content of the non-nitrile additive is preferably 0.1-30 mass %, and more preferably 0.1 to 10 mass %, based on the total amount of the non-aqueous electrolyte solution.” Ex. 1007 ¶ [0041]. Inexplicably, Dr. Lucht opines that “to the extent a POSITA sought to use an advantageous amount of PP in Zeng’s electrolyte, Matsuoka provides, and explains the benefits of, such an amount” and “Matsuoka therefore disclose *a weight percentage of the PP is Z.*” Ex. 1003 ¶ 144 (emphasis in original); *see also*, ¶ 141 (“Matsuoka...explicitly discloses an appropriate amount of PP (Z)”). I disagree and it is my opinion that Matsuoka does not teach, render, or disclose the claimed “weight percentage of the propyl propionate” (Z) “based on the total weight of the electrolyte” at least because Matsuoka provides no significance of propyl propionate from among the numerous non-nitrile additives as discussed *supra* Section VI.B.1, such that a POSITA would not select propyl propionate let alone apply such non-nitrile additive ranges to propyl propionate.

177. Moreover, Dr. Lucht fails to appreciate that Matsuoka’s preferred non-nitrile additive ranges are applicable to the sum or aggregate of *all* non-nitrile

additive components, not just a single non-nitrile additive. *See e.g.*, Ex. 1007 ¶¶ [0035] (“the non-nitrile additives includes substances that are not directly associated with electrochemical reactions, and they are used by a single use of one ingredient or by a combined use of two or more ingredients. From the viewpoint of the durability of SEI, the non-aqueous electrolyte solution of the present embodiment preferably contains two or more of the non-nitrile additives.”), [0038] (“These compounds are used singly or in combination of two or more”). Significantly, in addition to n-propyl propionate and isopropyl propionate, Matsuoka identifies multiple components that overlap with Zeng’s Embodiments 4 and 6 as example non-nitrile additive compounds. Ex. 1007 ¶¶ [0038], [0040]. For example, Matsuoka identifies at least ethyl propionate (EP) and monofluorobenzene (FB) as “non-nitrile additives”, both of which also have such LUMO and HOMO energies “falling in or near the most-preferred ranges,” which Dr. Lucht purportedly considers of importance. Ex. 1007 ¶¶ [0036], [0039]; Ex. 1003 ¶ 143. Accordingly, even if one were to assume that Dr. Lucht’s application of Matsuoka’s non-nitrile additive ranges to the alleged combination of Zeng and Hirai is reasonable and justified, it is my opinion that such non-nitrile additive ranges would apply to the sum or aggregate of *all* overlapping components in Zeng’s Embodiments 4 and 6, not just propyl propionate. As such, there would be numerous variables for the

POSITA to adjust (e.g., amounts, presence, and combinations of multiple non-nitrile additives) such that there would be no “explicit[] disclos[ure of] an appropriate amount of PP (Z)” (Ex. 1003 ¶ 141), and none of which Dr. Lucht addresses or considers in his hindsight-based opinion.

178. At least inasmuch as Matsuoka fails to render obvious the claimed “weight percentage of the propyl propionate” (Z) “based on the total weight of the electrolyte,” Matsuoka necessarily fails to render obvious the claimed Y/Z range of element [14.7]. For example, Dr. Lucht’s calculations of “0.1 to 10” and “0.033 to 10” based on Matsuoka’s “preferred ranges” of non-nitrile additives, respectively (Ex. 1003 ¶ 152), as applying only to propyl propionate and allegedly overlapping the claimed Y/Z range of about $0.01 \leq (Y/Z) \leq \text{about } 0.3$ is unjustified. The lack of disclosure of Matsuoka with respect to any significance of propyl propionate and the inapplicability of Matsuoka’s “preferred ranges” to just propyl propionate were already discussed hereinabove.

179. Moreover, at least in view of Zeng’s teachings of low viscosity (Ex. 1006 ¶ [0032]) and the common knowledge of the POSITA that, as compared to ethyl propionate (EP), propyl propionate (PP) has a larger molecular mass and longer chain (which lead to a higher viscosity than EP), the POSITA would be motivated to apply any alleged Matsuoka non-nitrile additive teachings to EP,

thereby increasing the amount of EP to the highest point of such non-nitrile additive range in Matsuoka and decreasing the amount of PP to the lowest point of such non-nitrile additive range in Matsuoka (i.e., 0.1 wt%) corresponding to a Y/Z value of 10 (based on Dr. Lucht's assumptions and calculations (Ex. 1003 ¶ 152)), which Y/Z value of 10 necessarily falls outside the claimed range of "about $0.01 \leq (Y/Z) \leq$ about 0.3."

3. The '131 Patent's Claimed Y/Z Ranges are Critical

180. Even if one were to assume that Dr. Lucht's flawed assumptions and calculations are reasonable and justified, and that Matsuoka discloses a range of Y/Z values that fall within or overlap the claimed range of independent claim 14, it is my opinion that the '131 Patent clearly establishes that the claimed range of Y/Z values in independent claim 14 is critical to providing the advantages that the '131 Patent's invention provides, whereas Matsuoka does not. That is, the '131 Patent explains that its specific weight percentage ratio ranges, including Y/Z values of 0.01-0.3 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 4.45V and more effectively reduce DC internal resistance of the battery. Ex. 1001, 1:55-62 ("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”) (emphasis added); 28:59-64 (“***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.***”) (emphasis added).

181. On the other hand, as discussed *infra* at Section VI.B.4, although a few of the examples in Matsuoka include a dinitrile as an additive, *none* of the examples include a trinitrile as an additive such that Matsuoka did not and could not verify the effect of trinitrile compound(s) together with propyl propionate, let alone suggest the criticality of the claimed Y/Z relationship.

182. Moreover, at least inasmuch as the non-nitrile additive ranges of Matsuoka apply to all such “non-nitrile additives” present in an electrolyte solution, and not just propyl propionate, the POSITA would not understand Matsuoka to suggest the criticality of the claimed Y/Z relationship. Dr. Lucht’s assertions that “Matsuoka also directs the POSITA to PP, specifically, by highlighting PP’s ability

to keep the battery's internal resistance low" and "a POSITA [] would have applied Matsuoka's teaching that PP effectively keeps internal resistance low to optimize PP content in Zeng's Embodiments 4 and 6, experimenting within Matsuoka's ranges" (Ex. 1003 ¶ 153) are nothing more than hindsight-contrived purposes that necessarily fail for all the reasons discussed *supra* at Section VI.B.1 (e.g., Matsuoka's lack of disclosure as to any particular significance of propyl propionate, let alone the applicability of the non-nitrile additive ranges to just propyl propionate).

183. Additionally, Dr. Lucht fails to take into account the fact that Matsuoka's disclosure of "an increase in internal resistance caused by repeating charge-discharge cycles can be suppressed" is with respect to Matsuoka's non-nitrile additive having a certain LUMO energy *relative to acetonitrile*. Ex. 1007 ¶ [0036]. That is, Matsuoka teaches that "[s]ince the *LUMO energy of acetonitrile calculated by the DFT calculation is 0.98 eV*, the specific [non-nitrile] additive of the present embodiment is a compound that is *reduced more sufficiently than acetonitrile* and this suggests that the electrochemical reaction progresses more quickly than the reductive decomposition of acetonitrile." *Id.* (emphasis added).

184. Moreover, the LUMO and HOMO energies of Matsuoka are considered relative to the *organic lithium salt* required in Matsuoka. See Ex. 1007 ¶ [0020]

(“The term ‘organic lithium salt’ is used herein to mean a lithium salt that is ***soluble in acetonitrile containing a carbon atom in the anion thereof***” and “[t]he present inventors have ***analyzed in detail the electrochemical reactivity of the organic lithium salt*** according to a computational chemical method, and as a result, they have discovered the range of a LUMO (lowest unoccupied molecular orbital) energy and the range of a HOMO (highest occupied molecular orbital) energy of the anion, ***which are able to suppress the reductive decomposition of acetonitrile and an increase in internal resistance.***”)(emphasis added). Accordingly, as discussed below in Section VI.B.4, the electrolyte systems of Zeng and Matsuoka are fundamentally different such that the POSITA would not extend any alleged internal resistance suppression disclosure or any other alleged benefits of Matsuoka to a non-acetonitrile-based electrolyte solvent system or an inorganic lithium salt-based electrolyte system. As such, the POSITA would not consider Matsuoka to “highlight[] PP’s ability to keep the battery’s internal resistance low” or otherwise “optimize PP content in Zeng’s Embodiments 4 and 6, experimenting within Matsuoka’s ranges” as alleged by Dr. Lucht. Ex. 1003 ¶ 153.

185. Accordingly, it is my opinion that, based on Zeng, Hirai, and Matsuoka, there is no reason for a POSITA to use a trinitrile compound as a component of an improved electrolyte composition, let alone provide a POSITA with any indication

that certain ratios of dinitrile, trinitrile, and propyl propionate have advantageous properties.

4. Petitioner Fails to Show That a POSITA Would have Combined Matsuoka with Zeng and Hirai

186. Moreover, a POSITA would not be motivated to combine Matsuoka with Zeng and Hirai as alleged by Dr. Lucht. In alleging some teaching, suggestion, or motivation to combine Matsuoka with Zeng, Dr. Lucht opines that “[t]o the extent Zeng’s recipe is hypothetically unclear about how much PP to use, that would have prompted the POSITA to consider Matsuoka’s teachings about appropriate amounts of PP to include in Zeng’s electrolytes.” Ex. 1003 ¶ 148. I disagree at least inasmuch as there is nothing in Zeng would instigate, prompt, or motivate the POSITA to look beyond Zeng for any purported “implementation details” and Petitioner and Dr. Lucht are simply contriving some purpose in hindsight for why a POSITA would look beyond Zeng when no such reason exists. Contrary to Dr. Lucht’s assertion, the POSITA would not be prompted to look beyond Zeng and “consider Matsuoka’s [alleged] teachings about appropriate amounts of PP to include in Zeng’s electrolytes” because Zeng provides an amount of propyl propionate to include in relative mass ratio in the base solvent mixture and the weight percentage of propyl propionate in the final electrolyte solution is simply not important to Zeng.

187. Moreover, I further disagree with Dr. Lucht's opinion that a POSITA "would have reasonably expected success in using Matsuoka's preferred non-nitrile weight proportions for PP in Zeng's electrolytes." Ex. 1003 ¶ 150. The electrolyte component "buckets" of Zeng and Matsuoka are not comparable such that comparisons or applicability of amounts or ranges between the two references is comparing apples to oranges. Matsuoka identifies at least propyl propionate (PP), ethyl propionate (EP), and monofluorobenzene (FB) as "non-nitrile additives". Ex. 1007 ¶¶ [0038], [0040]. Zeng considers and accounts for at least propyl propionate (PP), ethyl propionate (EP), and fluorobenzene (FB) as solvent components in the initial solvent mass ratio, not as additives. Ex. 1006 ¶ [0037]. Accordingly, a POSITA would not identify the teachings of Matsuoka as applicable to Zeng, and would have no reason to expect that any applicability of amounts or ranges of Matsuoka's additive components to the same components found in Zeng's solution as solvent components (especially in view of Zeng's solvents being in a defined solvent mass ratio in Embodiments 4 and 6) would have any success or predictable results given the inherent unpredictability of the interactions of these components. As such, a POSITA would not expect or have a "desire for balanced performance" as alleged by Dr. Lucht. Ex. 1003 ¶ 149.

188. In addition, the electrolyte solutions of Zeng include dinitriles and in some instances, a trinitrile, as additive(s). *See e.g.*, Ex. 1006 ¶¶ [0045]-[0049]. Indeed, Embodiments 4 and 6 of Zeng include only adiponitrile (a dinitrile), 1,2-bis(2-cyanoethoxy)ethane (a dinitrile), and 1,3,6-hexanetricarbonitrile (a trinitrile) as minor *additives*. *Id.* Matsuoka considers a fundamentally different nitrile—acetonitrile (a mononitrile)—to not only be essential to its electrolyte solution, but as the solitary or main *solvent* component. *See e.g.*, Ex. 1007 ¶ [0043] (“The content of acetonitrile is preferably 10 to 100 vol %, more preferably 70 to 100 vol %, and further preferably 90 to 100 vol %, based on the total amount of ingredients contained in the non-aqueous electrolyte solution, other than the organic lithium salt, and in a case in which the non-aqueous electrolyte solution contains an inorganic lithium salt, based on the total amount of ingredients contained in the non-aqueous electrolyte solution, other than the organic lithium salt or the inorganic lithium salt.”), ¶ [0109], and Tables 3-5 (setting forth numerous electrolyte solution examples with acetonitrile as the sole solvent component or the primary solvent component). Although a few of the examples in Matsuoka include a dinitrile as an additive, none of the examples include a trinitrile as an additive, and so a POSITA would consider the electrolyte systems of Zeng and Matsuoka to be fundamentally different.

189. Indeed, Matsuoka teaches that “by adjusting the content of the non-nitrile additive in the above described [0.1 to 30 mass %] range, **the excellent performance of acetonitrile can be sufficiently exhibited without impairing a basic function as a non-aqueous secondary battery.**” Ex. 1007 ¶ [0043] (emphasis added). Because Embodiments 4 and 6 of Zeng do not contain acetonitrile, a POSITA would not be given the slightest indication as to whether the preferred range of non-nitrile additives described in Matsuoka as advantageous for an acetonitrile solvent-based electrolyte would have any positive effect on other electrolyte solutions which do not contain acetonitrile as a solvent component, such as Zeng. Accordingly, I disagree with Dr. Lucht’s opinion that “Zeng’s and Matsuoka’s electrolyte compositions are substantially similar” (Ex. 1003 ¶ 150) because a POSITA would not consider turning to or using Matsuoka at least because the electrolyte systems are fundamentally different.

190. Not only are the electrolyte systems of Zeng and Matsuoka fundamentally different, but a POSITA would not have “a reasonable expectation of success” or “expect the resulting electrolyte combination to have significant benefits described in both references” (Ex. 1003 ¶¶ 150-151) at least because Matsuoka teaches away from the mixed solvent electrolyte systems of Zeng due to its lower discharge capacity at low temperatures (a focus of Zeng) such that a POSITA would

not consider Matsuoka's teachings applicable to Zeng's mixed solvent electrolyte systems. For example, Table 3 of Matsuoka (reproduced below), sets forth the solvent(s) in each electrolyte solution S1-S23:

TABLE 3

Electrolyte solution (d)									
Mother electrolyte solution (D)									
No.	Solvent	Organic		Inorganic		Additive			
		lithium salt		lithium salt		Additive 1		Additive 2	
		No.	Conc. [mol/L]	No.	Conc. [mol/L]	No.	Conc. [mass %]	No.	Conc. [mass %]
S1	Acetonitrile	L1	1	—	—	—	—	—	—
S2	Acetonitrile	—	—	L7	1	—	—	—	—
S3	Acetonitrile	L1	1	—	—	A1	10	—	—
S4	Acetonitrile	L2	1	—	—	—	—	—	—
S5	Acetonitrile	—	—	L8	1	—	—	—	—
S6	Acetonitrile	L3	1	—	—	—	—	—	—
S7	Acetonitrile	L1	1	—	—	A2	5	—	—
S8	Acetonitrile	L1	1	—	—	A3	10	—	—
S9	Acetonitrile	L1	1	—	—	A3	1	—	—
S10	Acetonitrile	L1	1	—	—	A4	30	—	—
S11	Acetonitrile	L1	1	—	—	A5	5	—	—
S12	Acetonitrile	L1	1	—	—	A6	5	A7	20
S13	Acetonitrile	L1	1	—	—	A8	5	A9	5
S14	Acetonitrile	L4	1	—	—	A3	3	—	—
S15	Acetonitrile	L2	1	—	—	A1	10	—	—
S16	Acetonitrile	L4	1	—	—	—	—	—	—
S17	Acetonitrile	L1	1	—	—	A10	5	—	—
S18	Acetonitrile	L1	1	—	—	A1	30	—	—
S19	Acetonitrile/ethylene carbonate/methyl ethyl carbonate (mass ratio = 30/21/49)	L1	1	—	—	A3	5	—	—
S20	Acetonitrile/ethylene carbonate/methyl ethyl carbonate (mass ratio = 13/29/58)	L1	1	—	—	A4	5	—	—
S21	Ethylene carbonate/methyl ethyl carbonate (volume ratio = 3/7)	—	—	L7	1	—	—	—	—
S22	Ethylene carbonate/methyl ethyl carbonate (volume ratio = 1/2)	—	—	L7	1	A1	10	—	—

Ex. 1007, Table 3.

191. Table 9 of Matsuoka (reproduced below) sets forth the measurement results for discharge capacity at low temperatures for some example monolayer laminate batteries (SL1) and small batteries (SC1) with various electrolyte solutions:

TABLE 9

	Elec- trolyte		Battery evaluation	Discharge capacity [mAh]		
	solution	Battery		-30° C.	-20° C.	25° C.
Example 21	S3	SL1	2-1	5.37	7.36	8.40
Example 22	S18	SL1	2-1	4.73	7.21	8.42
Example 23	S19	SL1	2-1	3.61	6.73	8.50
Example 24	S20	SL1	2-1	2.80	6.45	8.31
Comparative Example 8	S21	SL1	2-1	1.32	6.33	8.50
Example 25	S3	SC1	2-2	2.11	2.34	3.20
Comparative Example 9	S22	SC1	2-2	1.53	2.08	3.13

Ex. 1007, Table 9.

192. A POSITA would understand that when acetonitrile is used as the only solvent, such as in Matsuoka's Examples 21 and 22 of the prepared monolayer laminate batteries (SL1), the low temperature discharge capacity of the corresponding battery is higher than that of the mixed solvent systems. As another example, the electrolyte solution of Example 23 contains acetonitrile, ethylene carbonate, and methyl ethyl carbonate in a 30/21/49 mass ratio, the electrolyte solution of Example 24 contains acetonitrile, ethylene carbonate, and methyl ethyl carbonate in a 13/29/58 mass ratio, and the electrolyte solution of Comparative Example 8 contains ethylene carbonate and methyl ethyl carbonate in a 3/7 volume ratio. Ex. 1007, Table 3, Table 9. Notably, the acetonitrile single solvent-based

electrolyte solution of Example 21 has low-temperature discharge capacities of 5.37 mAh (-30°C) and 7.36 mAh (-20°C) and the acetonitrile single solvent-based electrolyte solution of Example 22 has discharge capacities of 4.73 mAh (-30°C) and 7.21 mAh (-20°C), which are higher than the low-temperature discharge capacities of Example 23 (3.61 mAh (-30°C) and 6.73 mAh (-20°C)), Example 24 (2.80 mAh (-30°C) and 6.45 mAh (-20°C), and Comparative Example 8 (1.32 mAh (-30°C) and 6.33 mAh (-20°C)).

193. Similarly, in Example 25 of the prepared small battery (SC1), acetonitrile is used as the only solvent and the electrolyte solution of Comparative Example 9 contains ethylene carbonate and methyl ethyl carbonate in a 1:2 volume ratio. Ex. 1007, Table 3, Table 9. Notably, the acetonitrile single solvent-based electrolyte solution of Example 25 has low-temperature discharge capacities of 2.11 mAh (-30°C) and 2.34 mAh (-20°C), which are higher than the low-temperature discharge capacities of Comparative Example 9 (1.53 mAh (-30°C) and 2.08 mAh (-20°C)).

194. Accordingly, a POSITA would interpret Matsuoka as teaching away from mixed solvent electrolyte systems because Matsuoka's single solvent acetonitrile electrolyte systems outperformed such mixed solvent electrolyte systems in low-temperature discharge capacity measurements.

195. Not only are the solvents of the electrolyte systems of Matsuoka and Zeng materially different, but the lithium salts used in the electrolyte systems are also different and a POSITA would understand Matsuoka to teach away from the single inorganic lithium salt of Zeng. That is, the only lithium salt used in Embodiments 4 and 6 of Zeng or disclosed generally by Zeng, is hexafluorophosphate (LiPF_6). *See e.g.*, Ex. 1006 ¶ [0037]. The non-aqueous electrolyte solution of Matsuoka, however, requires, in addition to acetonitrile, “an organic lithium salt, wherein an anion of the organic lithium salt has a LUMO [] energy in the range of -2.00 to 4.35 eV, and a HOMO [] energy in the range of -5.35 to -2.90 eV.” Ex. 1007 ¶ [0014]. According to Matsuoka, an organic lithium salt “is soluble in acetonitrile” and “contain[s] a carbon atom in the anion thereof”, wherein the anion satisfying such LUMO and HOMO energy requirements is “able to suppress the reductive composition of acetonitrile and an increase in internal resistance.” Ex. 1007 ¶ [0020].

196. LiPF_6 is an inorganic lithium salt having a LUMO of 4.05 eV and a HOMO of -5.39 eV. Ex. 1007 ¶ [0029] and Table 1 (LiPF_6 is identified as lithium salt L7). Accordingly, although Matsuoka identifies LiPF_6 as preferable when used in combination with the required organic lithium salt (Ex. 1007 ¶ [0030]), LiPF_6 does not meet the organic lithium salt requirements or the HOMO requirements

(-5.39 eV falls outside the HOMO range) of the required organic lithium salt of Matsuoka.

197. In addition, a POSITA would understand an electrolyte solution using only the inorganic lithium salt LiPF_6 (like Zeng and Hirai) to be fundamentally different from, and to have a much lower discharge capacity than, an electrolyte solution using an organic lithium salt as required by Matsuoka. For example, Example 1 of Matsuoka is a monolayer laminate type battery (SL1) prepared using a 1 mol/L LiBOB (organic lithium salt) electrolyte solution containing acetonitrile and Comparative Example 1 is a monolayer laminate type battery (SL1) prepared using a 1 mol/L LiPF_6 (inorganic lithium salt used in Zeng and Hirai) electrolyte solution containing acetonitrile. *See* Ex. 1007, Table 1 (identifying lithium salts L1-L9), Table 3 (identifying solvent(s), organic lithium salt(s), inorganic lithium salt(s), and additive(s) of electrolyte solutions S1-S22). As demonstrated in Table 6 of Zeng (reproduced below), it can be seen that the discharge capacity of Comparative Example 1 (0.07 mAh with only LiPF_6) is much lower than Example 1 (7.86 mAh with the required organic lithium salt of Matsuoka):

TABLE 6

	Electrolyte solution	Battery	Battery evaluation	Discharge capacity [mAh]
Example 1	S1	SL1	1-1	7.86
Comparative Example 1	S2	SL1	1-1	0.07
Example 2	S3	SL1	1-1	8.73
Example 3	S4	SL1	1-1	7.79
Comparative Example 2	S5	SL1	1-1	0.01

TABLE 6-continued

	Electrolyte solution	Battery	Battery evaluation	Discharge capacity [mAh]
Comparative Example 3	S6	SL1	1-1	0.03
Example 4	S3	SL1	1-2	8.44
Example 5	S7	SL1	1-2	8.49
Example 6	S8	SL1	1-2	8.30
Example 7	S9	SL1	1-2	8.21
Example 8	S10	SL1	1-2	8.36
Example 9	S11	SL1	1-2	8.54
Example 10	S12	SL1	1-2	8.25
Example 11	S13	SL1	1-2	8.33
Example 12	S14	SL1	1-2	8.99
Comparative Example 4	S2	SL1	1-2	0.07
Comparative Example 5	S5	SL1	1-2	0.01
Example 13	S3	SC1	1-4	3.10
Example 14	S15	SC1	1-4	3.11
Comparative Example 6	S6	SC1	1-4	0.01

Ex. 1007, Table 6.

198. Thus, I disagree with Dr. Lucht's suggestion that a POSITA reading the Zeng, Hirai, and Matsuoka references would have been motivated to reach the same solution that the inventors of the '131 Patent arrived at.

199. Claims 15-17 are not unpatentable over Zeng, Hirai, and Matsuoka for at least the reasons discussed above with respect to independent claim 14. I reserve the right to address claims 15-17 individually if this proceeding is instituted.

C. Ground 1C: Zeng, Hirai, and Kim '268, with or without Matsuoka, Do Not Render Obvious Claims 14-17

200. It is my understanding that in Ground 1C, Petitioner asserts and Dr. Lucht opines that Zeng, Hirai, and Kim '268, with or without Matsuoka, render obvious claims 14-17 of the '131 Patent. Pet., pp. 57-62; Ex. 1003 ¶¶ 154-166. In particular, Dr. Lucht opines that “Kim-'268 further focuses the POSITA on including both a trinitrile and PP in a dinitrile-based electrolyte and motivates adjusting relative amounts of these two components (i.e., Y/Z) to improve performance.” Ex. 1003 ¶ 157. It is my opinion that Kim '268 does not cure the failures of Zeng and Hirai or of Zeng, Hirai, and Matsuoka together, such that I disagree with Dr. Lucht for at least the following reasons.

201. For the same reasons noted above with respect to Zeng and Hirai in Ground 1A, it is my opinion that a POSITA would not have selected or implemented Embodiments 4 and/or 6 of Zeng; the disclosure of Zeng does not provide sufficient detail that would allow the POSITA to determine that Zeng discloses the weight percentages of propyl propionate (Z) or the claimed ratio of trinitrile to propyl propionate (Y/Z) of independent claim 14; Zeng says nothing about the critical claimed ratio of trinitrile to propyl propionate (Y/Z) of independent claim 14; and a POSITA would interpret Zeng as actually teaching away from use of a trinitrile compound as the addition of a trinitrile compound is a factor in *lowering* the capacity

retention rate in Zeng's Embodiments 4 and 6 (which contain a trinitrile) as compared to Embodiments 2 and 5 (which do not contain a trinitrile). Indeed, the POSITA would be deterred from Kim '268's use of a trinitrile compound at least because of Zeng's teachings.

202. For the same reasons noted above with respect to Zeng, Hirai, and Matsuoka in Ground 1B, it is my further opinion that a POSITA would not turn to Matsuoka to cure the failures of Zeng and Hirai. For example, nothing in Zeng would prompt a POSITA to look beyond Zeng to Matsuoka for any alleged "implementation details" regarding "appropriate amount[s] of PP" to include in Zeng's electrolytes, Matsuoka does not employ propyl propionate in any of its examples let alone identify any special significance or effect of propyl propionate among a list of 75+ possible compounds, Matsuoka's preferred non-nitrile additive ranges are applicable to the sum of all non-nitrile additive components, not just a single non-nitrile additive such as propyl propionate, the electrolyte component "buckets" of Zeng and Matsuoka are not comparable such that comparisons or applicability of amounts or ranges between the two references is unsupported, and the solvents and the lithium salt of the electrolyte systems of Zeng and Matsuoka are fundamentally different.

1. Petitioner Fails to Show that a POSITA Would Have Selected or Implemented Kim '268

203. Dr. Lucht argues that Kim-'268 “focuses the POSITA on including both a trinitrile and PP in a dinitrile-based electrolyte and motivates adjusting relative amounts of these two components (i.e., Y/Z) to improve performance.” Ex. 1003 ¶ 157. In particular, with reference to Table 1 of Kim '268, Dr. Lucht opines that “Kim-'268 Examples 1 and 2 (with trinitrile + PP) showed better thickness stability and capacity retention than Comparative Examples 1-6 (lacking one or both),” and that a POSITA “would recognize this superior performance stemmed from combining trinitrile and PP, focusing the POSITA on the importance of trinitrile- and PP-based electrolytes.” Ex. 1003 ¶ 160. Dr. Lucht also opines that “Kim-'268's Examples also highlight the superiority of PP, specifically,” because “Example 2 (with PP) outperformed Comparative Examples 5-6 (with MP or EP at same wt%) when substituting these alkyl propionates,” which “shows that PP performs better than similar alkyl propionates like MP or EP.” Ex. 1003 ¶ 161. Dr. Lucht further opines that Kim-'268 “shows optimizing the trinitrile (Y)/PP (Z) ratio affects performance: Examples 1 and 2 used identical dinitrile/trinitrile but varied PP (40 wt% versus 60 wt%), demonstrating PP's impact on battery performance.” Ex. 1003 ¶ 162. I disagree.

204. To better understand what a POSITA would be taught by Kim '268, we must examine with some detail Kim '268's experiments. This is difficult because Kim '268's experimental procedures are not articulated in any meaningful way—they are simply named, e.g. “thickness increase” (Ex. 1008, FIG. 3, FIG. 5, FIG. 7), “recovery capacity” (Ex. 1008, Table 2, FIG. 4, FIG. 6), “thickness variation ratio” (Ex. 1008, Table 2, Table 3, FIG. 4, FIG. 6), and “DC capa. to ini. capacity” (Ex. 1008, FIG. 7). Even though they are not defined, a POSITA might, with some effort, deduce from Table 2 what is meant by “recovery capacity” and “thickness variation” and how they might be calculated from underlying capacity and thickness measurements, respectively. However, the POSITA is still dependent on Kim '268 for how to understand and therefore interpret the underlying capacity and thickness measurements.

205. Kim '268 does not specify how its “capacity” values are measured. To evaluate the applicability of these data to a goal the POSITA might have, a POSITA would need to know additional details such as at what charge or discharge rate and between what voltage limits capacity was measured. When it comes to cycling data (*see* Ex. 1008, Table 4 and FIG. 7), a POSITA would need to know details of at what rate the cycling is performed, which is an independent rate that does not necessarily match the rate at which capacity is measured. Different tests may be used to measure

capacity and cycling, depending on the intended application. Likewise, Kim '268 does not specify how “thickness” values are measured. It is not clear whether the thickness corresponds to the total thickness of the cell at a particular location or from an ensemble of locations, how multiple values are treated, whether the thickness is measured under a particular state of charge/voltage and stack pressure, among other conceivable interpretations of “thickness”. In all cases, the measurements are not clear and, thus, would not be usable by the POSITA.

206. Nor does Kim '268 give any teachings as to why thickness has particular relevance to a particular battery performance outcome a POSITA might seek. Kim '268 mentions undesired gas generation (Ex. 1008 ¶¶ [0039], [0063]-[0064], [0104]-[0106]), for instance that “The electrolyte for a rechargeable lithium battery may exhibit low viscosity, excellent ion conductivity, and an excellent suppression effect on gas generation under a high voltage and a high temperature condition, and thus may effectively mitigate cell swelling at high temperature, and may improve cycle life characteristics, for example, in a high voltage battery of greater than or equal to about 4.4 V.” (Ex. 1008 ¶ [0039]). Notwithstanding that single oblique use of the word “swelling,” Kim '268 never directly connects thickness measurements to possible suppression (or not) of gas generation, and especially not to internal resistance, saying only that possible gas suppression

provides generic benefits: “the electrolyte according to an embodiment may help suppress gas generation in a high voltage battery and thus help improve cycle life characteristics of the battery.” Ex. 1008 ¶ [0066]. This is not because gas generation cannot be measured or otherwise observed in cell testing, if desired, only that Kim ’268 chose not to perform any such measurements despite seeming to care about that property. In spite of all this, Dr. Lucht attempts to make a connection between gas generation, thickness and internal resistance by citing the above paragraphs of Kim ’268, even though Kim ’268 itself does not make the connection: “Gas generation increases thickness and internal resistance of the battery, hurting storage and cycle performance, *Id.* ¶¶ [0039], [0063]-[0066].” Ex. 1003 ¶ 163.

207. Kim ’268’s data show, but Kim ’268 does not discuss, that its results are highly dependent on cell format. For example, Kim ’268 at Paragraph [0095] describes that Examples 1 and 2 and Comparative Examples 1 to 6 are embodied in prismatic cells. However, at Paragraph [0099], Kim ’268 describes embodiments of same Examples 1 and 2 and Comparative Examples 1 to 6 as pouch cells. No description is given as to how the respective prismatic and pouch cells are manufactured or are otherwise distinct from each other, nor are there teachings as to how they should be comparatively judged. For instance, a POSITA comparing “recovery capacity” results from the prismatic Example 1 (Ex. 1008, Table 2) would

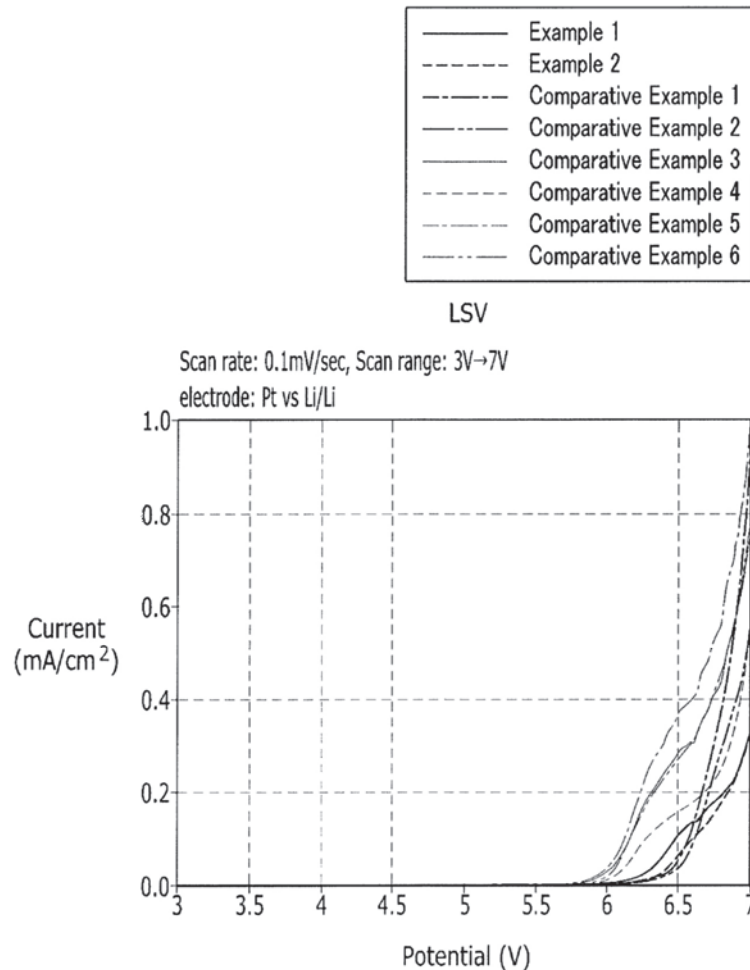
see 89.4% and from the pouch Example 1 (Ex. 1008, Table 3) would see 93.9%. This notable capacity difference or uncertainty of 4.5% for two embodiments of Example 1 exceeds the capacity differences between Example 1 and Comparative Examples 2, 3, 4, and 6 in Table 2. A POSITA cannot reliably judge that Example 1 is superior in recovery capacity to these supposedly dissimilar cases.

208. Similar divergence between Table 2 and Table 3 results for other properties and examples are manifest. The POSITA would then infer that there is a comparatively wide band of statistical uncertainty in the measurements made for each Example and Comparative Example in the two cell formats. First, this would lead a POSITA to have less confidence in the individual measurements due to their manifest differences by cell format. Second, this would lead a POSITA to not make any conclusory judgements about the purported efficacy embodied in Examples 1 and 2 compared to Comparative Examples, because such comparisons cannot be reliably made according to established statistical principles.

209. Kim '268 at Paragraphs [0099] and [0100] states that the thermal aging measurements on pouch cells were made after being “allowed to stand at 60°C. for **3 weeks**,” whereas Table 3 indicates the measurements were made after being “allowed to stand at 60°C. for **4 weeks**.” Ex. 1008 ¶¶ [0099]-[0100] and Table 3 (emphases added). It is not clear which of these contradictory statements is correct.

210. FIG. 2 of Kim '268 (reproduced below) provides “linear sweep voltammetry” data, purporting to show that Examples 1 and 2 are more electrochemically stable electrolytes than Comparative Examples 1 to 6 would be at a particular electrode potential, meaning the smaller the current (vertical axis) at a particular potential (horizontal axis), the more stable the electrolyte. Ex. 1008, FIG. 2. First, a POSITA would note that one does not necessarily always want a more stable electrolyte. As discussed in Paragraph 82 above, one wants an electrolyte to react on the electrode and then passivate the electrode, so that an initial reaction is a desired trait as long as it subsequently ceases after a suitable break-in period. Second, it is obvious from FIG. 2 that those potentials far exceed (i.e. up to 7V) potentials anticipated on a high-voltage cathode (i.e. around 4.4V). Because of the vertical scale used, a POSITA cannot determine from the plot the stability/currents for Examples and Comparative Examples at more realistic potentials, i.e. around 4.4V. Third, contrary to Kim '268's assertion that Examples 1 and 2 are the most stable (Ex. 1008 ¶ [0094] (“Examples 1 and 2 showed a lower oxidation current at a higher voltage as compared with Comparative Examples”), Comparative Examples 1 and 2 actually have lower oxidation currents than Examples 1 and 2 at potential 6.5V, which is certainly a “higher voltage.” To summarize, Kim '268's limited teachings

as to the value of the “linear sweep voltammetry” data are not borne out, or are otherwise outright contradicted, by Kim '268's own data.



Ex. 1008, FIG. 2.

211. Although I disagree as to the relevance or application of Kim '268 to the problems faced by the inventors of the '131 Patent, even if a POSITA were to try to apply Kim '268, in my opinion, only Kim '268's measurement of cycle life

would be of possible relevance to considerations made in the '131 Patent, meaning that a POSITA interested in extending the cycle life of cells in the manner of the '131 Patent would assign more relevance to that measurement than other of Kim '268's measurements. However, Kim '268 lacks any information on how the battery cell was cycled, which would prevent a POSITA from combining the teachings of Kim '268 and Zeng (with or without Matsuoka) and Hirai with a reasonable expectation of success. Indeed, key information for assessing the performance of Kim '268's batteries is missing, such as the voltage limit to which the battery is charged or discharged and at what rate the cycling is performed. Given Kim '268's focus on increasing the thermal stability of a battery, (*see* Ex. 1008 ¶¶ [0055] and [0056]), information on how the battery was cycled is particularly relevant as even small differences in operating voltages, such as during charging, can have significant effects on battery life. Moreover, even if Kim '268 provided information regarding how the battery cell was cycled, Kim '268's summary of cycle life in Table 4 is inconsistent with the data presented in FIG. 7, removing any confidence that a POSITA would have with respect to Kim '268's presentation of data.

212. Although not explicitly stated by Kim '268, a POSITA would conclude using test calculations that the "Capacity retention" values in Table 4 of Kim '268 (reproduced below) are computed as the ratio of "Capacity after 250 cycles" to

“Initial capacity” in Table 4. Thus, “Capacity retention” in Table 4 corresponds directly to “DC capa. to ini. capacity” in Figure 7 of Kim ’268 (also reproduced below). And indeed, this correspondence is precisely confirmed by reading Example 1, Example 2, Comparative Example 1, and Comparative Example 2 values from Figure 7 at 250 cycles and comparing these values to the values in Table 4. Furthermore, Kim ’268 invites the reader to make this comparison: “Referring to Table 4 and FIG. 7, the Examples showed much higher capacity retention after 250 cycles....” Ex. 1008 ¶ [0103].

213. However, a problem arises when comparing the capacity retention values for the remaining Comparative Examples, namely Comparative Examples 3, 4, 5, and 6. In Figure 7, for example, Comparative Examples 5 and 6 have a 250-cycle capacity retention of around 92.5% and 92.3%, respectively. However, in Table 4, these capacity retentions are reported at much lower values of 75.8% and 75.3%, respectively. Similarly, in Figure 7, the 250-cycle capacity retention of Comparative Example 3 is around 88.9%, whereas in Table 4 the 250-cycle capacity retention of Comparative Example 3 is 92.0%. Meanwhile, there is no capacity retention curve for Comparative Example 4 in Figure 7 by which to make a comparison with Table 4. To summarize, there are notable unexplained discrepancies between Figure 7 and Table 4 capacity retention values, which

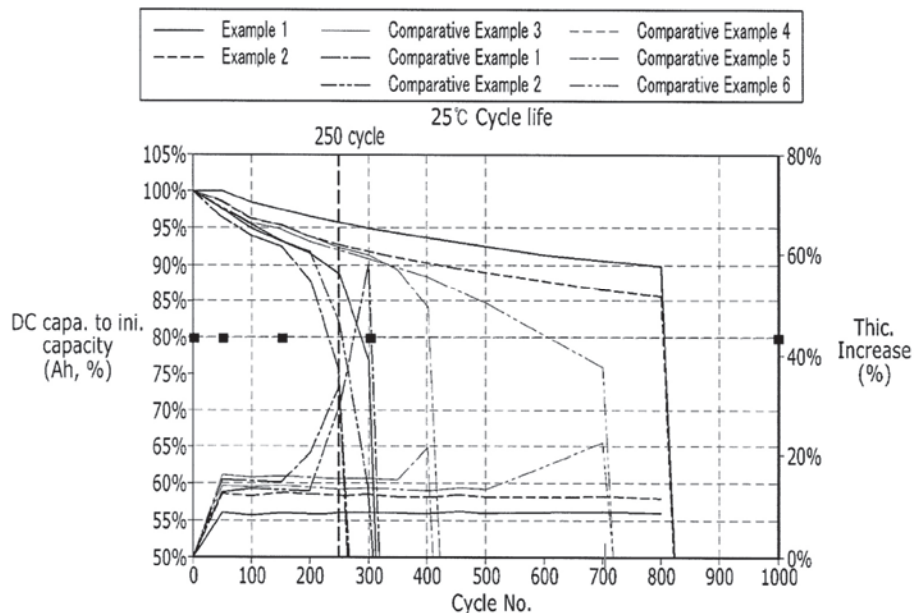
ultimately would deter a POSITA, who is presumably to receive teachings from Kim '268, from applying Kim '268.

TABLE 4

	initial capacity [mAh]	Capacity after 250 cycles [mAh]	Capacity retention	Initial thickness [mm]	Thickness after 250 cycles [mm]	Thickness variation ratio
Example 1	2112	2021	95.7%	3.32	3.61	8.7%
Example 2	2109	1956	92.7%	3.30	3.60	9.2%
Comparative Example 1	2040	1532	75.1%	3.27	4.39	34.4%
Comparative Example 2	2099	1720	82.0%	3.25	4.23	30.2%
Comparative Example 3	2061	1895	92.0%	3.28	3.73	13.6%
Comparative Example 4	2105	1870	88.9%	3.29	3.71	12.8%
Comparative Example 5	2122	1608	75.8%	3.26	3.78	15.7%
Comparative Example 6	2060	1551	75.3%	3.28	3.73	13.6%

Ex. 1008, Table 4.

FIG. 7



Ex. 1008, FIG. 7.

214. I disagree with Dr. Lucht's suggestion that Examples 1 and 2 of Kim '268 motivate adjusting relative amounts of propyl propionate and a trinitrile. Ex. 1003 ¶¶ 157-166. This suggestion by Dr. Lucht appears to hinge on his analysis that Examples 1 and 2 are superior to Comparative Examples 5 and 6 in Kim '268. Ex. 1003 ¶¶ 159-162. Even if a POSITA were to retain confidence in Kim '268's data, which is suspect in multiple respects as discussed above, a POSITA would note that Example 1 is superior to Example 2 in Kim '268's data on cell cycle life, as shown in Table 4 and FIG. 7. Therefore, a POSITA seeking to maximize cycle life would be taught by Kim '268, if anything, to consider Example 1's composition as superior to Example 2's composition. In particular, this requires substitution of a portion of the PP and PC solvent fractions used in Example 2 with a substantial EP solvent fraction used in Example 1. This would teach the POSITA away from using an even higher fraction of PP than is used in Example 1, which is 40 vol% of the base solvent (i.e. not including salt or additives) and would draw the POSITA's attention, if any, to the ratio of PP to EP (rather than PP to HTC� as Dr. Lucht opined, *see* Ex. 1003 ¶ 160).

215. Moreover, the teachings of Kim '268 also do not mandate the presence of PP (propyl propionate) and other alkyl propionates, such as variations of butyl (C4) or pentyl (C5) propionate are disclosed. Ex. 1008 ¶¶ [0013]-[0014] ("C3 to C5

alkyl propionate”). For example, as stated in Kim ’268, propyl propionate is one example of a C3 to C5 alkyl propionate which may be included individually, or in combination with other C3 to C5 alkyl propionates, in an amount of 10 volume percent to 80 volume percent based on the total amount of the organic solvent. Ex. 1008 ¶¶ [0040]-[0041]. Despite no experiments being performed on C4 or C5 alkyl propionate compounds, Kim ’268 describes the C3 to C5 alkyl propionate as being not particularly limited (*see e.g.*, Ex. 1008 ¶ [0088] and claim 3) and no preference is given to propyl propionate. Indeed, Kim ’268 provides no direct comparison between different C3-C5-alkyl propionates that would motivate selection of propyl propionate over another C3-C5-alkyl propionate discussed in Kim ’268. Thus, the POSITA would not make any inference about the efficacy of various alkyl propionates and at best would see a suggestion from Example 1 that substituting C3 alkyl propionate (PP) with C2 alkyl propionate (EP) is beneficial. Accordingly, I disagree with Dr. Lucht that a POSITA would be taught by Kim ’268 to use propyl propionate as the most efficacious alkyl propionate compound, especially when used exclusively (to the exclusion of other compounds). To wit, the presence of propyl propionate is not mandatory from the teaching of Kim ’268 and other alkyl propionates, such as variations of butyl (C4) or pentyl (C5) propionate are disclosed. Ex. 1008 ¶¶ [0013]-[0014] (“C3 to C5 alkyl propionate”).

216. Moreover, Kim '268 fails to provide a POSITA with any guidance with respect to a ratio of a *weight percentage* of a trinitrile compound to a *weight percentage* of propyl propionate *based on a total weight of the electrolyte*. That is, the solvents of Kim '268 are only disclosed in *volume percentages, based on the total amount of the organic solvent*. Ex. 1008 ¶ [0013], Table 1. Thus, Kim '268 does not contain an *explicit* disclosure of the amount of propyl propionate in the unit of weight percentage “based on a total weight of the electrolyte,” as is required in independent claim 14, and in turn, the claimed Y/Z ratio. Kim '268 also does not contain an *implicit* disclosure of the amount of propyl propionate in the unit of weight percentage based on a total weight of the electrolyte. That is, no information can be taken from Kim '268 that would allow a POSITA to convert the volume percentages mentioned therein into weight percentages. For example, Kim '268 provides no information regarding experimental parameters, such as the temperature under which the volume percentages of propyl propionate mentioned therein were determined. Density for each electrolyte constituent uniquely varies with temperature and so a given set of volume ratios of constituents mixed at a given temperature necessarily leads to a set of constituent weight ratios that is unique to the temperature. To make the conversion between volume ratios and weight ratios of the base solvent mixture, a POSITA, at a minimum, would need to know the

temperature at which the mixing is to be done. Kim '268 does not disclose the density or specify the temperature for one to attempt any calculation of weight percentages. Moreover, Kim '268 does not provide specific details regarding the manner or state in which the lithium salt is added to the electrolyte solution. For example, Kim '268 simply indicates that the lithium salt, LiPF_6 , is "1.15M" in Examples 1 and 2 and Comparative Examples 1-6. *See* Ex. 1008 Table 1; *see also*, ¶¶ [0023] ("A concentration of the lithium salt may be about 0.1 M to about 2.0 M."); [0052] ("The lithium salt dissolved in an organic solvent supplies a battery with lithium ions to operate the rechargeable lithium battery, and helps improve transportation of the lithium ions between positive and negative electrodes."); [0054] ("The lithium salt may be used in a concentration ranging from, for example, about 0.1 M to about 2.0 M. When the lithium salt is included at the above concentration range, an electrolyte may have excellent performance and lithium ion mobility due to optimal electrolyte conductivity and viscosity."). Thus, like Zeng, the POSITA can interpret the lithium salt in Kim '268 as being added in solution (i.e., lithium salt dissolved in unknown organic solvent to form 1.15M solution that is then added to the solvent mixtures identified in Kim '268) such that the relative weight percentages of propyl propionate and/or any trinitrile in Kim '268 cannot be determined or controlled. Thus, Kim '268 fails to provide a POSITA with any guidance as to a ratio

based on weight percentages of components, let alone weight percentages of the components based on a total weight of the electrolyte. Indeed, a POSITA would not be motivated to turn to Kim '268 from Zeng at least because the solvents of Zeng are set forth in a relative mass ratio and Kim '268 only discloses its solvents in *volume percentages*.

217. Additionally, ethylene carbonate (EC), a major electrolyte constituent used in every Example and Comparative Example of Kim '268 (*See* Ex. 1008 Table 1), is a sticky crystalline solid at typical laboratory temperatures, having a melting point of $36.4\text{ }^{\circ}\text{C} = 97.5\text{ }^{\circ}\text{F}$. Ex. 2040.^{11,12} It would therefore be extremely difficult and inconvenient to measure the volumetric amount of non-liquid EC as implied in Kim '268 Table 1 without first heating the EC to an elevated temperature at which it would melt and stay melted until it could be mixed—but Kim '268 does not

¹¹ Ex. 2040 (*Ethylene Carbonate*, https://www.m-chemical.co.jp/en/products/departments/mcc/c2/product/1200981_7910.html (last visited on June 8, 2025)).

¹² Note that even though pure EC is a solid at room temperature, like conventional lithium salts, if it is mixed with low-melting-point solvents in appropriate ratios, the mixed electrolyte may be a liquid at room temperature.

provide any description of how this is to be done or what temperature was used, meaning there is yet another scientific perplexity or gap that would discourage a POSITA from following the teachings of Kim '268. Moreover, Kim '268 is nonsensical at least inasmuch as the volume sum of the solvents in each Example is 100% yet Kim '268 still purports to add additives and lithium salt (in solution) for which the volume is not accounted. Ex. 1008, Table 1.

218. Additionally, Kim '268's Examples 1 and 2 and Comparative Examples 1 to 6 use dinitrile amounts of 3 wt% or 1 wt% and use trinitrile amounts of 0 or 2 wt%. In all cases, dinitrile plus trinitrile amounts uniformly sum to 3 wt%. In the language of the '131 Patent, all of Kim '268's embodiments are $X+Y = 3 \text{ wt\%}$ and X/Y is either 0.5 or infinity (i.e. divide by zero). Thus, despite Dr. Lucht's suggestion otherwise, there is little variation and no experimentation in Kim '268 to suggest to a POSITA that there should be preferred or critical range of values for the combination of dinitrile (X) and trinitrile (Y) compounds. Moreover, as shown above, the measurements of Kim '268 are inadequately described by Kim '268, scientifically problematic, and/or have no explicated connection to such objectives.

2. Petitioner Fails to Show that a POSITA Would have Combined Kim '268 with Zeng and Hirai, with or without Matsuoka

219. In my opinion, a POSITA would not be motivated to combine Kim '268 and Zeng. For example, in addition to not containing any teaching to prevent increases in the internal DC resistance of a battery, Kim '268 also does not contain any teachings to improve electrode plate wettability and interfacial compatibility, which are main objectives of Zeng. *See e.g.*, Ex. 1006, Abstract. Instead, Kim '268 aims to increase the thermal stability of a battery through the use of “an electrolyte additive including greater than or equal to about three nitrile groups.” Ex. 1008 ¶¶ [0055]-[0056]. Kim '268 describes that this purpose may be further served by the optional addition of an additive, which is intended to suppress the generation of gas in the electrodes during storage at high temperatures. Ex. 1008 ¶ [0064]. The additive may be selected from a variety of classes of compounds and may be present in a wide range of concentrations from about 0.01 to 20% by weight of the total weight of the electrolyte composition. Ex. 1008 ¶¶ [0064]-[0065]. Examples 1 and 2 include succinonitrile (the only dinitrile compound mentioned at all in Kim '268) as an example of this additive, but Kim '268 provides no single comparative example investigating whether succinonitrile has a beneficial effect on the electrolyte compositions.

220. A POSITA would also not be motivated to combine Kim '268 and Matsuoka. As discussed above in Section VI.B.4. with respect to Zeng, Hirai, and Matsuoka, the electrolyte systems of Matsuoka and Kim '268 are fundamentally different. Examples 1 and 2 of Kim '268 each use a single inorganic lithium salt (LiPF_6) and are not acetonitrile solvent-based electrolytes. A POSITA would have understood that Matsuoka teaches away from such solvent electrolyte systems that are not acetonitrile solvent-based electrolytes, as well as the use of the single inorganic lithium salt LiPF_6 . As such, a POSITA would not be motivated combine Matsuoka with Kim '268, Zeng, and Hirai.

221. Moreover, I disagree with Dr. Lucht's assertion that the '131 Patent "echoes" Kim '268. Ex. 1003 ¶ 164. Citing the '131 Patent (and not Kim '268), Dr. Lucht asserts that "Kim-'268 explains that while adding trinitrile creates a durable cathode SEI film, such film-forming battery internal resistance and thickness expansion, hurting performance." Ex. 1003 ¶ 164.

222. In fact, Kim '268 states, "the additive [which may be selected from a variety of classes of compounds] may be used in an amount of, for example, about 0.01 wt % to about 20 wt%, for example, about 0.1 wt% to about 10 wt% or about 0.1 wt % to about 5 wt % based on the total weight of the electrolyte," and "[w]hen the additive is used within the range, the electrolyte may have a minimized film

resistance increase and contribute to improving battery performance.” Ex. 1008 ¶¶ [0064]-[0065]. That is, as discussed above, Kim ’268 aims to improve battery performance by increasing the thermal stability of a battery through the use of an additive that may be selected from a variety of classes of compounds and may be present in a wide range of concentrations from about 0.01 to 20% by weight of the total weight of the electrolyte composition. *Id.* Although Examples 1 and 2 of Kim ’268 include succinonitrile (the only dinitrile compound mentioned at all in Kim ’268) as an example of this additive, Kim ’268 provides no single comparative example investigating whether succinonitrile has a beneficial effect on the electrolyte compositions. Moreover, as Dr. Lucht acknowledges (*see* Ex. 1003 ¶ 165), Kim ’268 does not contain any teaching to prevent increases in the internal DC resistance of a battery, which is a main objective of the ’131 Patent (*see supra* Section IV.C.). Nor would a POSITA be led to “evaluat[e] Kim-’268’s electrolytes for PP’s internal resistance effects” since “DC resistance testing was routine” and “would have been standard practice.” Ex. 1003 ¶ 165. Battery performance can be measured in numerous ways and which test(s) a POSITA would choose is dependent on a number of factors (including the battery’s intended application) such that no one test is “routine” as asserted by Dr. Lucht.

223. In my opinion, even a cursory examination of the battery development literature over the last 200 years or even last decade would show a practically unlimited list of possible experiments one could perform, and there is certainly no consensus on which battery tests are routine. For instance, cells have been adapted for measurements by instruments or techniques such as mass spectrometry, optical microscopy, electron microscopy, x-ray diffraction, neutron diffraction, nuclear magnetic resonance, stress and strain, and gas pressure, among many other analytic techniques. *See e.g.*, Ex. 2032.¹³ This is not to mention the multiplicity of electrochemical interrogation techniques such as determining cell responses to transient, scanning, and steady-state electrical perturbations. *See e.g.*, Ex. 2033.¹⁴ Individual cell components and electrolytes may similarly be evaluated chemically and mechanically. And of course, any of the properties recovered are functions of

¹³ Ex. 2032 (Jerome Workman, Jr., *A Comprehensive Review of Spectroscopic Techniques for Lithium-Ion Battery Analysis*, 39 *Spectroscopy* 6 (2024), <https://doi.org/10.56530/spectroscopy.ii3689u3>).

¹⁴ Ex. 2033 (Anup Barai et al., *A Comparison of Methodologies for the Non-Invasive Characterisation of Commercial Li-Ion Cells*, 72 *Prog. Energ. Combust. Sci.* 1 (2019)).

temperature, state of charge of the cell, and thermal and cycling history of the cell. Moreover, if the DC internal resistance measurement as taught in the '131 Patent is a "routine procedure," as Dr. Lucht asserts, then Dr. Lucht would be able to point to numerous examples in the Petitioner's exhibits, including Kim '268, wherein this measurement was performed, which he has not done.

224. Claims 15-17 are not unpatentable over Zeng, Hirai, and Kim '268, with or without Matsuoka, for at least the reasons discussed above with respect to independent claim 14. I reserve the right to address claims 15-17 individually if this proceeding is instituted.

D. Ground 2A: Zeng and Hirai, Further in View of Han, Do Not Render Obvious Claim 15

225. Petitioner contends that Zeng, Hirai, and Han further render obvious claim 15 of the '131 Patent.

226. For at least the reasons discussed above with respect to Ground 1A, claim 15 is also not unpatentable. It is my further opinion that Han does not and cannot cure the deficiencies of Zeng and Hirai. I reserve the right to further address additional issues with Han and claim 15 individually if this proceeding is instituted.

E. Ground 2B: Zeng, Matsuoka, and Hirai, Further in View of Han, Do Not Render Obvious Claim 15

227. For at least the reasons discussed above with respect to Grounds 1A, 1B, and 2A, claim 15 is also not unpatentable. It is my opinion that Han and

Matsuoka do not and cannot cure the deficiencies of Zeng and Hirai. I reserve the right to address additional issues with Han and Matsuoka and claim 15 individually if this proceeding is instituted.

F. Ground 2C: Zeng, Hirai, Han, and Kim '268, with or without Matsuoka, Do Not Render Obvious Claim 15

228. For at least the reasons discussed above with respect to Grounds 1A, 1B, 1C, 2A, and 2B, claim 15 is also not unpatentable. It is my opinion that Matsuoka, Kim '268, and Han do not and cannot cure the deficiencies of Zeng and Hirai. I reserve the right to address additional issues with Matsuoka, Kim '268, and Han and claim 15 individually if this proceeding is instituted.

G. Ground 3A: Zhou and Hirai Do Not Render Obvious Claims 14-17

229. Petitioner contends that Zhou and Hirai render obvious claims 14-17 of the '131 Patent. Pet., 62-75; Ex. 1003 ¶¶ 167-204. I disagree that Zhou and Hirai render obvious any of claims 14-17 for at least the following reasons.

230. Dr. Lucht relies on the disclosure of Zhou for all elements of independent claim 14, except for elements [14.4]-[14.6], which recite, *inter alia*, [14.4] wherein, the electrode comprises a first electrode and a second electrode, [14.5] wherein the first electrode comprises a first current collector and a single-sided coating, and [14.6] electrode compaction densities and an electrode

compaction density ratio, for which Dr. Lucht allegedly relies on the disclosure of Hirai. Ex. 1003 ¶¶ 167-204.

231. Zhou is directed to a fast-charging lithium-ion battery electrolyte solution to provide certain fast charging requirements and battery cycling performance with a voltage of 4.35V, the electrolyte solution using a solvent including a mixture of two or more of low-boiling point linear carbonate and a linear carboxylic acid ester, fluorobenzene, and hydrofluoroether, a lithium salt, and three additives including “a first additive for negative electrode film formation, a second additive for improving battery cycle performance, and a third additive for improving battery high temperature performance.” Ex. 1014, Abstract. Zhou conducts battery cycling performance and AC impedance testing on lithium-ion batteries made with these electrolyte solutions to test the effect that the electrolyte systems have on performance and AC impedance of the batteries. *Id.* ¶¶ [0021]-[0024], [0048]-[0051], [0056]-[0057], [0060]-[0064].

232. Zhou is directed to a fundamentally different problem than the '131 Patent. Unlike Zhou, the claims of the '131 Patent are directed to three components—a dinitrile compound, a trinitrile compound, and propyl propionate—mixed in specific weight percentage ratio ranges 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 4.45V and effectively reduce DC internal resistance of the battery. Ex. 1001, 1:55-62 (“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”). Indeed, as set forth in the ’131 Patent, “[t]he 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.” Ex. 1001, 28:59-64. Zhou says nothing about this critical ratio or that its electrolyte solutions can effectively inhibit the increase in DC internal resistance of the electrochemical device.

233. 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, it is my understanding that Petitioner points to the electrolyte composition disclosed for Example 8 of Zhou, and alleges that this electrolyte composition, as would allegedly be modified by the POSITA to substitute propyl

propionate (PP) for ethyl acetate (EA), renders obvious the claimed electrolyte of claim 14. *See* Pet., pp. 62-72, 74.

234. For the reasons below, it is my opinion that a POSITA would not have selected or implemented Zhou in general or Example 8 of Zhou in particular.

235. It is also my opinion that Dr. Lucht relies on numerous improper assumptions with respect to his analysis of Example 8.

236. It is also my opinion, for the reasons below, that a POSITA would not substitute propyl propionate (PP) for ethyl acetate (EA) in Example 8 of Zhou, as evidenced by at least the numerous unsupported and incorrect assumptions, calculations, and arguments made by Dr. Lucht.

237. Dr. Lucht relies on the disclosure of Hirai for element [14.4], which recites, wherein, the electrodes comprise a first electrode and a second electrode, element [14.5], which recites, wherein the first electrode comprises a first current collector and a single-sided coating; the second electrode comprises a second current collector and a double-sided coating, and element [14.6], which recites, an electrode compaction density of the first electrode comprising the single-sided coating is D1, and, an electrode compaction density of the second electrode comprising the double-sided coating is D2, wherein, about $0.8 \leq D1/D2 \leq$ about 1.2. Ex. 1003 ¶¶ 200-202 (Dr.

Lucht purportedly incorporating by reference his analysis with respect Hirai from the Zeng/Hirai combination of Ground 1A).

238. As discussed previously in Section VI.A., Hirai is directed to a laminated-structure battery. Ex. 1010, Title. In particular, Hirai is focused on “suppressing output unevenness of the single cells at a center portion and an end portion [of a laminated-structure battery] and improving durability by making the A/C ratio [the capacity ratio of the anode capacity to the cathode capacity] at the center portion in the direction of lamination higher than the A/C ratio at the end portion.” Ex. 1010 ¶ [0010].

239. After describing six means for allegedly making the A/C ratios of single battery layers higher closer to the center portion of a laminated-structure battery as compared to the end portion in the direction of lamination, Hirai describes 6 examples and 2 comparative examples of laminated-structure batteries comprising five layers of single battery layers, each of the single battery layers including a $\text{Li}(\text{Ni}_{0.8}\text{Co}_{0.1}\text{Al}_{0.1})\text{O}_2$ (NCA) cathode, a natural graphite anode, and an EC:DEC (5:5 molar ratio) electrolyte layer and conducts capacity retention and energy density testing with respect to each example/comparative example:

TABLE 17

	Capacity retention (500 cyc)	Energy density
Example 1	83%	92
Example 2	80%	92
Example 3	80%	93
Example 4	81%	91
Example 5	82%	100
Example 6	80%	100

TABLE 17-continued

	Capacity retention (500 cyc)	Energy density
Com. Ex. 1	76%	85
Com. Ex. 2	74%	100

Ex. 1010 ¶ [0286], Table 17.

240. Hirai is directed to a fundamentally different problem than the '131 Patent. Unlike Hirai, the '131 Patent's claims are directed to three components—a dinitrile compound, a trinitrile compound, and propyl propionate—combined in specific weight percentage ratio ranges that unexpectedly provided the benefit of forming 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 4.45V and effectively reduce DC internal resistance of the battery. Ex. 1001 at 1:55-62, 28:59-64. Moreover, the '131 Patent describes a synergistic effect between the combined electrolyte additives and the electrode compaction density ratio. Ex. 1001, 31:53-57 ("It can be seen that when D1/D2 is within the range of 0.8-1.2, *a better cycle performance is obtained, possibly because the*

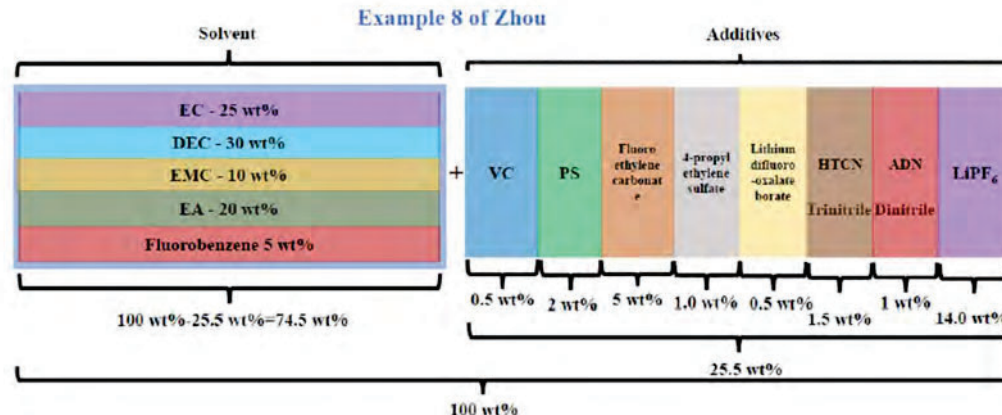
combined additives facilitate the reduction of the electrode interface resistance and the reduction of the cell polarization.”) (emphasis added). Hirai is silent with respect to this critical formula and any such synergistic effect of the combined electrolyte additives and the electrode compaction density ratio. Accordingly, Hirai is simply focused on purportedly addressing output unevenness to improve performance. Hirai is not concerned with any synergistic effect between electrolyte additives and electrode compaction density ratio as compared to the '131 Patent.

241. For the reasons below, it is also my opinion that Hirai fails to disclose the claimed “electrode compaction density of the first electrode comprising the single-sided coating is D1” and, in turn, the claimed electrode compaction density ratio (D1/D2).

242. It is also my opinion that a POSITA would not be motivated to combine Hirai with Zhou.

1. Petitioner Fails to Show that a POSITA Would Have Selected or Implemented Zhou in general or Example 8 of Zhou in particular

243. It is my understanding that Dr. Lucht opines that a POSITA would have been motivated to implement Example 8 of Zeng, asserting that the original electrolyte solution of Example 8 has the following composition:



Ex. 1003 ¶ 173, *see also*, ¶¶ 167-167.

244. It is my further understanding that Dr. Lucht opines that a POSITA would have substituted propyl propionate (PP) for the ethyl acetate (EA) in Example 8 of Zhou. Ex. 1003 ¶¶ 167-168, 173, 176, 188-197.

245. I understand that Dr. Lucht opines that Example 8 of Zhou, as modified with propyl propionate, contains a Z value of 16.56 wt%. Ex. 1003 ¶¶ 176 (“EA...has a weight ratio of...16.56%, which I denote as Z”), 177, 203 (table reflecting “Z (PP substituted for EA) as 16.56 wt%).

246. To obtain such alleged Z value in Example 8 of Zhou, I understand Dr. Lucht to have assumed that ethyl acetate (EA) forms 20 wt% of the solvent mixture, that the solvent mixture forms 74.5 wt% (1-25.5%) of the total electrolyte solution

of Example 8, and that propyl propionate (PP) was substituted for ethyl acetate (EA) at a 1:1 ratio:¹⁵

$$(1 - 25.5\%) \times \left(\frac{20\%}{25\% + 30\% + 10\% + 20\% + 5\%} \right) = 16.56\% \quad \text{Example 8}$$

Ex. 1003 ¶¶ 167, 177-178, 188.

247. It is my further understanding that Dr. Lucht further opined, based on this tenuous calculation of the weight percentage of propyl propionate, as substituted, and that modified Example 8 of Zhou, discloses a ratio of trinitrile to propyl propionate (*Y/Z*) of 0.091. Ex. 1003 ¶ 203.

248. For at least the reasons below, it is my opinion a POSITA would not have selected or implemented Zhou as its electrolyte formulation purposes are not aligned with the objective task underlying the '131 Patent.

249. The '131 Patent achieves 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 that is not easily decomposed, effectively inhibits the

¹⁵ The Equation is presented in the same form as Dr. Lucht depicted it in Paragraph 176 of Ex. 1003 with respect to Zhou, which is different from how Dr. Lucht depicted the Equation in Paragraph 73 of Ex. 1003 with respect to Zeng.

increase in DC internal resistance of the lithium ion battery, and achieves high capacity density, and excellent cycle and storage performances. Ex. 1001, 1:55-62, 3:8-20. That is, as discussed in the Technology Overview section of this Declaration, during the first charge of a lithium-ion battery, the electrolyte reacts with the respective electrode materials, undergoing reduction at the negative electrode (or anode), and oxidation at the positive electrode (or cathode). The reaction of the electrolyte causes a passive protective layer (the SEI), to form on the surfaces of the electrodes. The SEI contains a mixture of organic and inorganic electrolyte decomposition products and is very important to the function of the battery. Stable cathode SEI films, which can perform well at working voltages above 4.4V were of particular interest. At such “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” with an increasing number of charging cycles. *Id.* 22:24-29, 1:30-39; *see also* 1:32-37 (“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.”).

250. Accordingly, faced with such premature degradation of the electrolyte and thus deterioration of the battery material with reduced battery capacity, it was an objective task of the '131 Patent to provide electrolyte compositions which prevent such prior art problems, especially for electrochemical devices working at voltages above 4.4V, such as 4.45V.

251. In contrast, Zhou does not mention cathode SEI film formation or high-voltage operation. The objective of Zhou is a fast-charging electrolyte, which emphasizes better wettability, lower viscosity, and lower lithium-ion transmission resistance. Ex. 1014 ¶ [0003].

252. Moreover, Zhou is directed to batteries with a lower charging voltage of only 4.35V, which is much lower than the high working voltages of the objective task of the '131 Patent. While it might seem to one new to the battery field that 4.35V in Zhou is close to the 4.45V level of the '131 Patent, they are, in fact, substantially different. First, a POSITA trained in electrochemistry would understand that a small voltage difference can lead to substantial differences in rates of reaction—in this case, reactions that would lead to electrolyte or electrode degradation—because, in general, electrochemical reactions scale exponentially in voltage. Second, 4.35V is considered the extreme upper voltage limit for commercially produced cells employing LiCoO_2 (also known as LCO) cathodes, meaning that any operation over

short or long periods of time above this voltage limit would substantially impair the life of the battery. In my opinion, Zhou did not choose 4.35V arbitrarily, but rather to show that fast charging could be enabled for the at-the-time cutting-edge battery standard. A POSITA would understand that the 4.45V disclosed in the '131 Patent would be well outside the conventional operating limit for both cell safety and longevity.

253. Prior to the '131 Patent, the primary solution to such above-described decomposition and premature degradation was to add a film-forming additive to the electrolyte. “However, doing so [caused] 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.” Ex. 1001, 22:31-34. Accordingly, faced with such problem, a POSITA would find Zhou’s AC impedance testing/focus to be insufficient. That is, the DC internal resistance of the '131 Patent is different from the AC impedance studied in Zhou. While the two methods do both measure some common phenomena, they are not the same. *See, e.g.*, Ex. 2033. For example, DC internal resistance represents the resistance when the battery is in working condition and produces a weighted average of multiple operationally relevant resistances. DC internal resistance is particularly relevant to the power performance of the battery and its performance when under load, and is of great significance to the battery’s

discharge capacity and charging efficiency. This parameter can be measured by an instrument designed for controlling and measuring current and voltage of the test cell, such as a potentiostat.

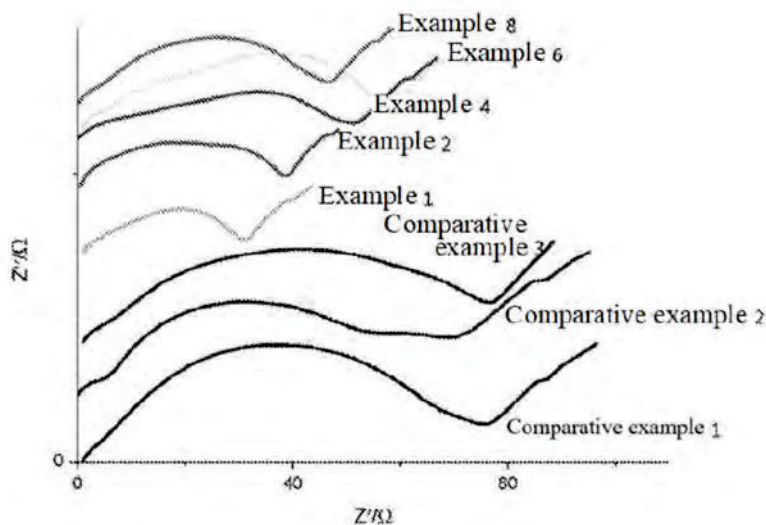
254. The determination of AC impedance, however, involves injecting a sinusoidal current signal of a specific frequency into the cell, and synchronously detecting a sinusoidal voltage across the cell, thereby deriving the AC impedance of the battery. AC impedance is used in battery research and development, quality control, and electrochemical analysis because it is designed to give a linear response that can be better understood. However, the linear response means the AC measurement does not generally incorporate “polarization,” which happens when a cell in operation experiences large potential and concentration variations. In contrast, DC internal resistance captures polarization effects and better provides real-world operational assessment.

255. It is my further opinion that a POSITA would not have selected or implemented Zhou at least because there are multiple erroneous references to different or non-existent comparative examples in nearly every Example and Comparative Example set forth in Zhou. That is, the final sentence of each of the descriptions of Comparative Examples 2 and 3 and Examples 1-8 refers to a different or non-existent Comparative Example, thereby introducing uncertainty in the

intention of Zhou with respect to the Examples. *See e.g.*, Ex. 1014 ¶¶ [0028]-[0029] (“**Comparative Example 2**...and then 14.0% by mass of LiPF_6 is slowly added and stirred until it is completely dissolved to obtain the lithium-ion battery electrolyte of **Comparative Example 1**.”), ¶¶ [0038]-[0039] (“**Example 4**...and then 14.0% by mass of LiPF_6 is slowly added and stirred until it is completely dissolved to obtain the lithium-ion battery electrolyte of **Comparative Example 6**.”), ¶¶ [0046]-[0047] (“**Example 8**...and then 14.0% by mass of LiPF_6 is slowly added and stirred until it is completely dissolved to obtain the lithium-ion battery electrolyte of **Comparative Example 8**.”) (emphases added).

256. In support of his rationale to implement Example 8 of Zhou, Dr. Lucht opines that “a POSITA would have selected and implemented Zhou Example 8” because “[t]he Example 8 battery significantly performed the Comparative Example batteries in discharge capacity and low impedance and **outperformed other Examples in low impedance**.” Ex. 1003 ¶ 180 (citing Ex. 1014 ¶¶ [0057], [0061], FIGS. 1, 4); *see also*, Ex. 1003 ¶ 182 (Dr. Lucht asserting that “Example 8 outperformed Examples 3-6 in discharge capacity and **outperformed Examples 1, 2, 4, and 6 in internal impedance**.”) (emphases added). Dr. Lucht’s interpretations of FIG. 4 of Zhou are wrong.

257. FIG. 4 of Zhou provides:

**FIG. 4**

Ex. 1014, FIG. 4.

258. FIG. 4 is known as a Nyquist plot, a way of presenting AC impedance data. It appears that Dr. Lucht assumed that Example 8 outperformed all of the other batteries depicted in FIG. 4 simply because it is positioned at the top of the figure. However, this is a misinterpretation of the data reflected in FIG. 4. Rather, the results for each of the different Examples 1, 2, 4, 6, and 8 and Comparative Examples 1, 2, and 3 are stacked so that the depicted spectra do not overlap for easier viewing by the reader. Paragraph [0058] of Zhou provides, in relevant part,:

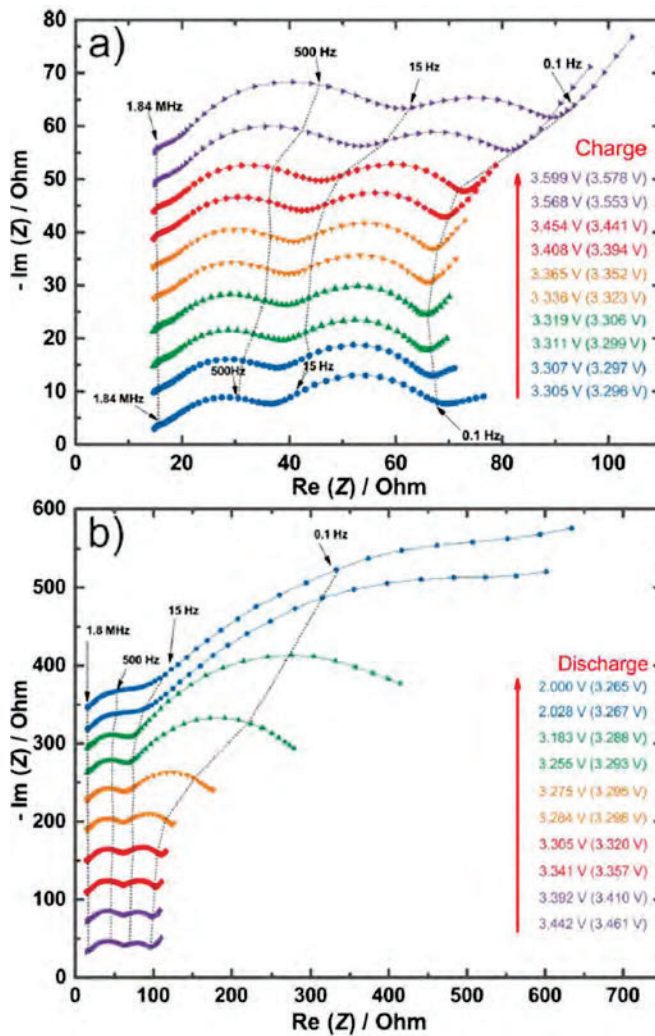
From Figure 4, it can be found that the corresponding semicircle in the AC impedance curve can characterize the impedance behavior of lithium-ions in the SEI film. **The larger the radius of the arc, the worse the kinetic**

performance, and the smaller the radius, the better the kinetic performance of the battery.

Ex. 1014 ¶ [0058] (emphasis added).

259. Zhou's choice to present vertically offset or stacked curves in FIG. 4 is less common in Nyquist-type battery impedance plots, however, is common in some kinds of chemical spectroscopy; nevertheless, another example of vertically offset or stacked curves in a Nyquist-type battery impedance plot may be found in FIG. 4 of Ex. 2023¹⁶ (reproduced below).

¹⁶ Ex. 2023 (Wenbo Zhang et al., *Interfacial processes and influence of composite cathode microstructure controlling the performance of all-solid-state lithium batteries*, 9 ACS Applied Materials & Interfaces 17835 (2017)).



Ex. 2023, FIG. 4 (reflecting “[s]tacked Nyquist plots of [solid-state batteries] with LNT0-coated LiCoO₂ as active material during (a) the charge and (b) the discharge process”).

260. Accordingly, the key value is not the vertical placement of a spectrum, but rather the horizontal position of the elbow or sharp dip of the spectrum, with the elbow or sharp dip located further to the left being preferable as it indicates lower

“real” impedance for the electrode interface. The radius of each of Example 1 and 2 is smaller (i.e., the elbow or sharp dip is positioned further left) than the radius of Example 8 (i.e., the elbow or sharp dip is positioned further right). As such, Dr. Lucht misinterprets the results depicted in Zhou FIG. 4 at least inasmuch as Examples 1 and 2 both outperformed Example 8 with respect to AC internal impedance. Significantly, neither the electrolyte solution of Example 1 nor the electrolyte solution of Example 2 contain a trinitrile. Ex. 1014 ¶¶ [0032]-[0035]. It is my opinion that a POSITA would not have selected or implemented Example 8 over any of the other Examples of Zhou, and that Zhou teaches away from the electrolyte solution of Example 8 at least because Examples 1 and 2 both outperformed Example 8 with respect to AC internal impedance.

261. Moreover, FIG. 3 of Zhou is the only figure that depicts battery cycle performance at high temperatures. Ex. 1014 ¶¶ [0023] (“Figure 3 is a 1C/1C cycle performance test diagram of a battery prepared by the electrolytes of Comparative Examples 1, 2, 3 and Examples 1, 2, 5, and 6 at 45°C”), [0063] (“In order to further investigate the cycle performance of the battery at high temperature, a 1C/1C cycle performance test was conducted at 45°C”). The remaining figures depict testing results at room temperature or low temperature. Ex. 1014 ¶¶ [0024] (“Figure 4 is the AC impedance spectrum...at a low temperature of 10°C”), [0049] (“Room

temperature 2C/1C cycle experiment...and the results are shown in Figure 1”),
[0050] (“Room temperature 3C/1C cycle experiment...and the results are shown in
Figure 2”).

262. FIG. 3 of Zhou provides:

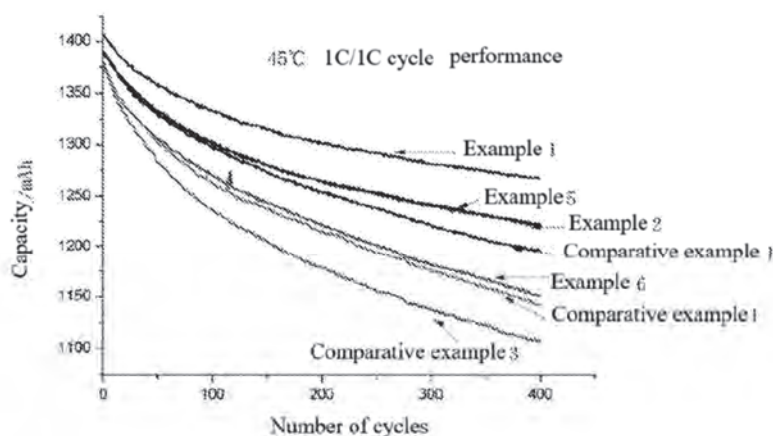


FIG. 3

Ex. 1014, FIG. 3.

263. Paragraph [0059] of Zhou provides, in relevant part,:

For the improvement of high temperature performance under high voltage of the fast charging system, among the nitrile compounds containing 2 or 3 nitrile functional groups in the third additive used in the present invention **to improve the high temperature performance of the battery, 1,3,6-hexane trinitrile is particularly preferred.** This is related to the poor compatibility of nitrile compounds with the negative electrode. **The high**

**temperature performance is often challenged when
using the solvent system of the present invention.**

Ex. 1014 ¶ [0059] (emphasis added).

264. The electrolyte solutions of Examples 4 and 8 of Zhou are the only examples that include a trinitrile, specifically, 1,3,6-hexane trinitrile. Ex. 1014 ¶¶ [0038]-[0039] (“1.5% by mass of 1,3,6-hexane trinitrile”), [0046]-[0047] (“1.5% by mass of 1,3,6-hexane trinitrile”). Significantly, neither Example 4 nor Example 8 are depicted in FIG. 3 such that a POSITA would not be able to draw any conclusions therefrom. Accordingly, it is my opinion that a POSITA would not have selected or implemented Example 8 over any of the other Examples of Zhou.

265. It is my further opinion that Zhou *teaches away* from the combination of a dinitrile compound and a trinitrile compound in its electrolyte solutions because the dinitrile contains less nitrile groups for the same volume, such that a POSITA would not have selected or implemented Example 8 because it contains both a dinitrile compound and a trinitrile compound. Ex. 1014 ¶ [0059], ¶¶ [0046]-[0047] (identifying “1.5% by mass of 1,3,6-hexane trinitrile and 1% by mass of adiponitrile” in Example 8). According to Zhou, “[a]n efficient high temperature additive is the best choice. Nitrile compounds containing 2 or 3 nitrile functional groups, **such as 1,3,6-hexane trinitrile, contain three nitrile groups, and the density of nitrile groups per unit volume is higher. It has better compatibility**

with the negative electrode and is easier to protect the positive electrode. The high temperature improvement effect of other dinitrile compounds or mononitrile compounds is relatively poor. This requires more nitrile to compensate. However, excessive addition of nitrile has a negative effect on the cycle performance, especially in the case of fast charging, this phenomenon is more obvious, and the cycle performance will drop rapidly.” Ex. 1014 ¶ [0059] (emphasis added). Zhou, accordingly, teaches away from using both dinitrile and trinitrile compounds in the same solution.

266. It is my further opinion that a POSITA would not have selected or implemented Example 8 over any of the other Examples of Zhou at least because there is no unambiguous data that would indicate to or encourage a POSITA to choose any particular embodiment of Zhou over another. For example, in FIGS. 1-4 of Zhou, none of the figures contain all of the Examples, no one Example is set forth in each figure, and no one Example consistently outperforms the other Examples or even all the Comparative Examples. *See e.g.*, Ex. 1014, FIG. 1 (Examples 1 and 2 are absent), FIG. 2 (Examples 3 and 6-8 are absent), FIG. 3 (Examples 3, 4, 7, and 8 are absent and Comparative Example 1 is depicted as having two distinct curves), and FIG. 4 (Examples 3, 5, and 7 are absent), ¶¶ [0060]-[0063].

267. It is my further opinion that a POSITA would not have selected or implemented Example 8 over any of the other Examples of Zhou based on a discrepancy in the solvent composition of Example 8. Dr. Lucht asserts that “[e]ach of Zhou’s Example electrolytes is a self-contained, working embodiment providing a complete list of compounds, amounts, and preparation instructions.” Ex. 1003 ¶ 179. However, the sum of the mass ratio of the solvent components in Example 8 **only adds up to 90**, while the mass ratios of all other Examples and Comparative Examples **add up to 100**. Compare Ex. 1014 ¶¶ [0046]-[0047] (“Example 8...mass ratio of 25:30:10:20:5) with Ex. 1014 ¶¶ [0032]-[0033] (“Example 1...mass ratio of 25:35:20:20”). Dr. Lucht never addresses this discrepancy and such discrepancy is only exacerbated by Dr. Lucht’s assumption that such mass ratio directly corresponds to *weight percentages* of the identified solvent components. See e.g., Ex. 1003 ¶ 173 (equating each solvent component relative mass ratio of 25:30:10:20:5 in Example 8 to weight percentages of 25 wt%, 30 wt%, 10 wt%, 20 wt%, and 5 wt%, respectively). It is unknown if there is an additional, different solvent component present at 10 wt% or if there is an additional 10 wt% of one or more of the identified solvent components. A POSITA would have disregarded Example 8 at least based on this weight discrepancy. I reserve the right to address this discrepancy in further detail if this *inter partes* review is instituted.

268. Accordingly, in my opinion, a POSITA would not have selected or implemented Zhou in general or Example 8 of Zhou in particular.

2. Dr. Lucht's Assumptions With Respect to His Analysis of Example 8 of Zhou are Improper

269. Dr. Lucht also relies on numerous improper assumptions with respect to his analysis of Example 8. For example, Example 8 of Zhou provides:

[0046] Example 8

[0047] In a glove box filled with argon (water content <10pm, oxygen content <1ppm), ethylene carbonate, dimethyl carbonate, ethyl methyl carbonate, ethyl acetate, and fluorobenzene are mixed uniformly in mass ratio of 25:30:10:20:5, 0.5% by mass of vinylene carbonate, 2% by mass of 1,3-propane sultone, 5% by mass of fluoroethylene carbonate, 1.0% by mass of 4-propyl ethylene sulfate, 0.5% by mass of lithium difluorooxalate borate, 1.5% by mass of 1,3,6-hexane trinitrile and 1% by mass of adiponitrile are added to the mixed solution, and then 14.0% by mass of LiPF₆ is slowly added and stirred until it is completely dissolved to obtain the lithium-ion battery electrolyte of Comparative Example 8.

Ex. 1014 ¶ [0046]-[0047].

270. In performing each of his calculations with respect to the alleged weight percentages of dinitrile, trinitrile, and propyl propionate, as well as the

corresponding claimed sums and ratios, Dr. Lucht, without explanation, erroneously relies on a central assumption that the mass percentages provided by Zhou in Example 8 for various additives (including ADN and HTC�) and for lithium salt are all based on the total mass of the final electrolyte solution. Ex. 1003 ¶ 173 (“When describing electrolyte compositions, Zhou specifies the weight percentages of additives to the solvent, including LiPF₆, based on ‘the *total mass* of the lithium-ion battery electrolyte’”) (citing Ex. 1014 ¶¶ [0009], [0013]-[0016], [0018]); *see also*, ¶¶ 174-177. That is, Dr. Lucht assumes that the denominator for determining the identified “% by mass” of each of the additives and the lithium salt is the total mass of the final electrolyte solution.

271. However, Example 8 of Zhou is silent as to what the identified mass percentages are relative. For example and in view of the silence regarding identified mass percentages, a POSITA would interpret Example 8 of Zhou such that the identified mass percentages of the additives and the lithium salt are relative only to the mass of the solvents, not the total mass of the electrolyte. In this interpretation, the denominator for determining the identified “% by mass” of each of the additives and the lithium salt is the mass of the solvents. Alternatively, the POSITA could interpret the identified mass percentages of the additives and salt differently, according to their respective placements in the sequence of mixing steps. In this

interpretation, the denominator for determining the identified “% by mass” of each of the additives is the mass of the solvents and the denominator for determining the identified “% by mass” of the lithium salt is the combined mass of the solvents and the additives. For example, in such interpretation, the POSITA understands Example 8 of Zhou to describe three steps: (1) mix solvents in mass ratio, (2) add the additives to the mixed solvents such that the identified mass percentages are based on the mass of the mixed solvents formed in Step 1, and (3) add the lithium salt such that the mass percentage is based on the combined mass of the solvent and additives mixture formed in Step 2. Based on the silence of Example 8 with respect to the relative measurement of the mass percentages, the POSITA logically understands that the mass percentages are calculated based on the mass of the mixture formed in the prior step.

272. The two interpretations in Paragraph 271 are based on a plain reading of the language found in Example 8, which describes a sequential mixing process in which solvent is mixed first and then all other constituents are treated as perturbations to this base mixture. Example 8, as do the other Examples, uses the language that additives “are added to the mixed solution” implying that the solvent mixture has distinct status as a base mixture. In view of the silence in Example 8 with respect to the determination of the mass percentages, Petitioner and Dr. Lucht

have failed to address at least these interpretations of the relative denominator of the mass percentages identified in Example 8 of Zhou. Dr. Lucht's flawed assumption that the mass percentages provided by Zhou in Example 8 for the various additives and for lithium salt are necessarily based on the total mass of the final electrolyte solution is erroneous and permeates each of his resulting calculations of the alleged weight percentages of dinitrile, trinitrile, and propyl propionate, as well as the corresponding claimed sums and ratios.

3. Petitioner Fails to Show that a POSITA Would Have Substituted Propyl Propionate for Ethyl Acetate in Example 8 of Zhou

273. It is my understanding that Dr. Lucht opines that "a POSITA would have found it 'obvious to try' substituting PP for EA in Zhou Example" and "replacing EA with PP in Zhou Example 8 constitutes a mere simple substitution of one known element (the ester EA) for another (the ester PP) to obtain predictable results." Ex. 1003 ¶¶ 189, 194. For the reasons set forth below, I disagree and it is my opinion that a POSITA would not have substituted propyl propionate (PP) for ethyl acetate (EA) in Example 8 of Zhou, as evidenced by at least the numerous unsupported and incorrect assumptions, calculations, and arguments made by Dr. Lucht.

274. Observing that Example 8 of Zhou contains “the linear carboxylic acid ester ethyl acetate (EA)”, Dr. Lucht concedes that “Example 8 lacks PP.” Ex. 1003 ¶ 167. However, Dr. Lucht asserts that “Zhou lists eight esters that are suitable replacements for EA, one being PP.” Ex. 1003 ¶ 167 (citing Ex. 1014 ¶ [0011]), see also, ¶ 191 (“Zhou identifies nine potential esters—one of which (EA) is used in Example 8, and another of which is PP.”) Dr. Lucht assumes that because “Zhou lists PP alongside EA in a short list of suitable esters,” “the POSITA would likewise expect PP to have the properties necessary to succeed in Zhou’s electrolytes.” Ex. 1003 ¶ 192 (citing Ex. 1014 ¶ [0057]). I disagree at least because although propyl propionate is identified as a potential linear carboxylic acid ester, there is no preference, special significance, or even the slightest indication for the POSITA to select propyl propionate for use in Zhou as propyl propionate is not used in any of the Comparative Examples or Examples of Zhou or otherwise tested for its actual functionality. *See* Ex. 1014 ¶¶ [0026]-[0048], [0052]-[0055]. As such, it would be impossible to predict the effect of propyl propionate in Zhou’s Example 8. The chemical interactions and effects of complex combinations of various compounds in electrolyte solutions are extremely complex and unpredictable, and a POSITA would not expect predictable results from adding propyl propionate in the place of EA.

275. Moreover, the POSITA would not “likewise expect PP to have the properties necessary to succeed in Zhou’s electrolytes” simply because Zhou lists PP alongside EA, as assumed by Dr. Lucht (Ex. 1003 ¶ 192). For example, Table 1 of Zhou provides the melting and boiling point data of some solvents used in Examples 1-8:

[0053] Table 1. Melting and boiling point data of solvents used in Examples 1-8

[0054]

Solvent	Melting Point/°C	Boiling Point/°C
Dimethyl carbonate	4.6	90
Ethyl methyl carbonate	-55	108
Ethyl acetate	-84	77.1
Ethyl propionate	-73.8	99
Butyl butyrate	-98	121.6
Fluorobenzene	-42	85

Ex. 1014 ¶¶ [0053]-[0054], Table 1.

276. Paragraph [0055] of Zhou further provides:

[0055] From the melting and boiling point data of some solvents in Examples 1-8 listed in Table 1, **it can be seen that the melting and boiling points of the linear carbonate and carboxylate solvents used in the present invention are both low**, providing a more suitable channel for lithium-ion transmission and reducing the impedance of the battery system.

Ex. 1014 ¶ [0055].

277. A POSITA would understand that having both a low melting point and a low boiling point correlates to lower viscosity, which allows the lithium ions to move more quickly, i.e., “providing a more suitable channel for lithium-ion transmission and reducing the impedance of the battery system.” Notably, propyl propionate has a melting point of -75.9°C, a boiling point of 122.5°C, and viscosity of 0.69 mPa/s at 20°C. Ex. 2024 (BYU DIPPR® (Design Institute for Physical Properties) Thermophysical Properties Laboratory Data Information Sheet for n-Propyl Propionate). Propyl propionate’s boiling point is nearly 50°C higher than the boiling point of ethyl acetate (77.1°C) and more than 20°C higher than ethyl propionate (99°C), the linear carboxylic acid esters used in Examples 1, 4, 6, and 8 and Examples 2, 3, 5, and 7, respectively. Indeed, propyl propionate’s boiling point is considerably higher than any other solvent in Table 1 that is used in Examples 1-8.¹⁷

¹⁷ Although “Butyl butyrate” is listed in Table 1 of Zhou, it is not used in any of Examples 1-8 or Comparative Examples 1-3. *See* Ex. 1014 ¶¶ [0026]-[0048]. Indeed, “butyl butyrate” is not identified as a linear carboxylic acid ester in Zhou (Ex. 1014 ¶ [0011]) nor are the identified melting point and boiling point correct for

278. Moreover, Dr. Lucht's arguments that "PP has a higher boiling point than EA [which] would improve battery safety without compromising performance" (Ex. 1003 ¶ 192), also fails because any such change would necessarily make such electrolyte inferior for viscosity and conductivity, which is the focus of Zhou. Propyl propionate's melting point (-75.9°C) is also nearly 10°C higher than the melting point of ethyl acetate (-84°C). Propyl propionate's viscosity (0.69 mPa/s at 20°C) is also 53% higher than the viscosity of ethyl acetate (0.45 mPa/s at 20°C).

279. Propyl propionate is also a much larger molecule and has a larger molar mass of 116.16 g/mol compared to the smaller molecule and molar mass of 88.106 g/mol of ethyl acetate. Compared to ethyl acetate, propyl propionate has a longer chain, with two additional methylene groups, such that propyl propionate has greater mutual intermolecular attractive forces, with the liquid molecules of propyl

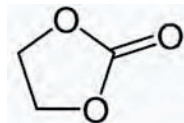
"butyl butyrate". Ex. 1014, Table 1. Rather, the noted melting point of -98°C and boiling point of 121.6°C appear to correspond more closely to the literature melting point and boiling point of "ethyl butyrate", which although is identified as a linear carboxylic acid ester in Zhou (Ex. 1014 ¶ [0011]), is also not used in any of Examples 1-8 or Comparative Examples 1-3. *See* Ex. 1014 ¶¶ [0026]-[0048].

propionate moving more slowly and being impeded by neighboring molecules and thereby increasing viscosity.

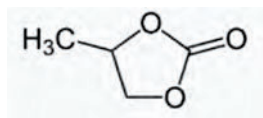
280. Accordingly, a POSITA seeking higher electrolyte conductivity as Zhou is would not have had a reasonable expectation of success in replacing propyl propionate for ethyl acetate in Example 8 of Zhou nor would the POSITA obtain predictable results in such a substitution. For example, propyl propionate is a larger molecule and such substitution would increase both the melting point and the boiling point relative to the smaller ethyl acetate molecule, which defeats Zhou's identified purpose of using this solvent component.

281. Moreover, the chemical reactions in a battery are unpredictable. The POSITA would understand that all of the components of an electrolyte are important and interact in complex and unexpected ways and substituting one component for another, even if apparently chemically similar, can cause substantial changes to properties of interest. Indeed, a component may promote one desirable property and simultaneously inhibit another desirable property. For example, ethylene carbonate (EC) and propylene carbonate (PC) have similar structures, but PC has one additional carbon atom:

Ethylene Carbonate (EC)



Propylene Carbonate (PC)



Their performances are very different, however. For example, EC can form a good SEI film on the surface of the carbon negative electrode, but PC cannot. This led to PC being rejected for use in Li-ion battery electrolytes for nearly 30 years, despite it having other desirable electrolyte properties.

282. Electrolyte components are subject to a complex matrix of requirements and tradeoffs and there is no obvious choice of such components for every application and objective. That is, there is no component that is universally beneficial, which makes it a complex decision on whether to include a component and how much to include of such component. Indeed, Dr. Lucht assumes that the propyl propionate would be substituted at a 1:1 weight percentage ratio, without accounting for such varying parameters (e.g., boiling point, viscosity, molecule size, molar mass, etc.) that defeat Zhou's identified purpose. *See e.g.*, Ex. 1003 ¶ 197 (Dr. Lucht asserting that "[w]ith this guidance, a POSITA could have simply added 20 wt% PP instead of 20 wt% EA during this process.")

4. Petitioner Fails to Show that Zhou and Hirai Render Obvious the Claimed D1 Electrode Compaction Density and the Claimed D1/D2 Ratio of Independent Claim 14, or that a POSITA Would Be Motivated to Combine Hirai with Zhou

283. Dr. Lucht admits that Zhou does not disclose elements [14.4]-[14.6], and instead relies on the disclosure of Hirai for such electrode and electrode compaction density elements. Ex. 1003 ¶¶ 199-202. Dr. Lucht also purportedly incorporates by reference his analysis with respect to Hirai from the Zeng/Hirai combination of Ground 1A. *Id.*

284. In particular, Dr. Lucht asserts that “[f]or the same reasons discussed above in Ground 1A [with respect to the Zeng/Hirai combination], it is my opinion that a POSITA would have found it obvious use Hirai’s electrode structure with Zhou’s lithium-ion batteries,” and “[l]ike Zeng, Zhou focuses on electrolytes rather than battery structures, so “a POSITA would have found it obvious [to] use Hirai’s electrode structure with Zhou’s lithium-ion battery.” *Id.* ¶ 201. Thus, inasmuch as Dr. Lucht incorporates his analysis with respect to Hirai from the Zeng/Hirai combination of Ground 1A, it is my opinion that Zhou and Hirai do not render obvious elements [14.4]-[14.6] for at least the reasons discussed above in Ground 1A. *Supra* Sections VI.A.3 and VI.A.4.

285. Additionally, Dr. Lucht asserts that “Zhou and Hirai are analogous art,” “Zhou focuses on electrolytes rather than battery structures, so a POSITA would have looked to Hirai for details to implement its improved electrode structure,” “Zhou specifically teaches that its lithium-ion batteries are used in large-battery applications in ‘electric vehicles, military, aerospace and other fields,” “Hirai states that ‘it is preferable to apply Hirai’s laminated (laminated structure) lithium ion secondary battery of the present embodiment to large-size batteries like on-vehicle batteries in particular” and “a POSITA would have had a reasonable expectation of success in doing so.” Ex. 1003 ¶¶ 201-202. For at least the same reasons noted above with respect to Hirai in Ground 1A, *supra* Section VI.A, I disagree with Dr. Lucht’s analysis with respect to Hirai and it is my opinion that Hirai is directed to a fundamentally different problem than the ’131 Patent and Hirai does not disclose anything that overcomes the criticality of the claimed D1/D2 range. Indeed, Dr. Lucht’s assertion that “Zhou specifically teaches that its lithium-ion batteries are used in large-battery applications in ‘electric vehicles, military, aerospace and other fields” ignores the fact that Zhou is generally describing lithium-ion batteries in its “Background technology” section, not a specific-use case for its batteries. Ex. 1014 ¶¶ [0002]-[0005] (titled “Background technology”). Moreover, Zhou lists at least the additional field of “3C digital products” (*id.*, ¶ [0002]) and Hirai specifically

distinguishes such consumer type products from its “large-size, laminated-structure batteries like [] on-vehicle batteries.” Ex. 1010 ¶ [0006] (“in contrast with small-size batteries of a winding structure generally used for cellular phones and mobile personal computers.”).

286. Moreover, the fact that Zhou recites a list of fields in which lithium-ion batteries are “widely used” that includes “and other fields” effectively covers *all* possible applications of lithium-ion batteries and makes any alleged focus on applications effectively meaningless at this level. *See, e.g.*, Ex. 1014 ¶ [0002]. The teachings of a reference become more meaningful once the reference considers specific battery application issues like safety; cost; manufacturing problems; longevity; rate, voltage and temperature of operation; etc. Indeed, the tests chosen to evaluate the embodiments are instructive on what matters vs. what does not. Accordingly, a POSITA would not be “specifically motivate[d]...to use Hirai’s large battery electrode structure in Zhou’s battery” as asserted by Dr. Lucht. Ex. 1003 ¶ 202.

287. It is also my opinion that a POSITA would not be motivated to combine Hirai with Zhou. There is no reason a POSITA would have looked to Hirai (or had a reasonable expectation of success in combining Hirai with Zhou) for battery implementation details when Hirai does not say anything about electrolytes, much

less the relationship between electrode compaction density and an electrolyte having the same or similar additives as Zhou.

288. Indeed, the high operating temperatures of Hirai leave the teachings of Hirai to be irrelevant and nontransferable to other systems, like Zhou, that have lower operating temperatures. For example, while Hirai's examples are cycle-tested at 50 °C, Zhou's examples are cycle tested at room temperature and a few of Zhou's examples (not even including Example 8 upon which Dr. Lucht relies) are cycle tested at 45 °C. *Compare* Ex. 1014 ¶¶ [0049]-[0051] (room temperature and 45 °C) *with* Ex. 1010 ¶ [0283] (50 °C). 50 °C is a high temperature to be performing cycling tests—even a 5 °C increase over 45 °C can lead to significant changes in outcomes such that a POSITA cannot apply the teachings of Hirai to Zhou. An elevated temperature is associated with accelerated testing, in which the temperature is used to make the cells fail more rapidly to test the effect of some variable during a timescale that is convenient for the tester. A POSITA would recognize that with accelerated testing different failure modes are affected by temperature to different degrees. When temperature is changed, the different failure modes become more or less significant compared to each other, as each has a unique dependence on temperature. *See, e.g.*, Ex. 2030.

289. Insofar as Zhou attempts to improve the electrolyte for high-rate charge and discharge battery operation and teaches nothing about how the configuration or compaction of coatings on the current collector would have bearing on such a problem, and insofar as Hirai attempts to solve an output unevenness problem and has nothing to teach about how electrolyte composition has bearing on such a problem, there is no logical connection between Zhou and Hirai. A POSITA would have no motivation to combine the two, just as a POSITA would have no motivation to combine Hirai with any other reference dealing with electrolyte issues. It is not until the inventors of the '131 Patent discovered an unexpected beneficial connection between electrolyte composition and compaction density.

290. Accordingly, it is my opinion that Zhou and Hirai do not render obvious at least the claimed D1 electrode compaction density, and in turn, the claimed D1/D2 ratio of independent claim 14, Zhou and Hirai do not overcome the criticality of the claimed D1/D2 range, and the POSITA would not be motivated to combine Hirai with Zhou.

5. Claims 15-17 Are Not Unpatentable

291. Claims 15-17 are not unpatentable for the same reasons as discussed above with respect to independent claim 14. I reserve the right to address claims 15-17 individually if this proceeding is instituted.

H. Ground 3C:¹⁸ Zhou, Hirai, and Kim '268 Do Not Render Obvious Claims 14-17

292. It is my understanding that in Ground 3C, Petitioner asserts and Dr. Lucht opines that Zhou, Hirai, and Kim '268 render obvious claims 14-17 of the '131 Patent. Pet., pp. 75-76; Ex. 1003 ¶ 209. In particular, Dr. Lucht asserts that “[f]or the reasons discussed above in Grounds 1C, 2C, it is my opinion that Kim-’268 motivates considering the ratio of trinitrile to PP in Zhou and substituting EA for PP in Zhou Example 8” as “Zhou highlights the advantage of trinitrile (HTCN) by explaining that it has ‘a high density of nitrile groups per unit volume’ and ‘better compatibility with the negative electrode and is easier to protect the positive electrode’”, “Zhou discloses substituting EA with PP,” “drawing attention to PP”, and “Zhou also cautions the POSITA against using an ‘excessive’ amount of PP for its ‘[] negative effect on the cycle performance,’ focusing attention on Y/Z.” Ex. 1003 ¶ 209. I disagree for at least the following reasons.

293. For at least the reasons discussed above with respect to Zhou and Hirai in Ground 3A, *supra* Section VI.G., claims 14-17 are not unpatentable.

294. It is my opinion that Kim '268 does not and cannot cure the deficiencies of Zhou and Hirai. As similarly discussed with respect to Grounds 1C and 2C

¹⁸ I note that Petitioner does not assert a “Ground 3B.”

hereinabove, Kim '268 is replete with internally contradicting data, statistical uncertainty, and woefully inadequate experimental procedure details from which a POSITA could draw any conclusions. For example, Kim '268 does not specify how “capacity” or “thickness values” are measured. To evaluate the applicability of these data to a goal the POSITA might have, a POSITA would need to know additional details such as at what charge or discharge rate and between what voltage limits capacity was measured. When it comes to cycling data (*see* Ex. 1008, Table 4 and Figure 7), a POSITA would need to know details of at what rate the cycling is performed, which is an independent rate that does not necessarily match the rate at which capacity is measured. With respect to thickness, it is not clear whether the thickness corresponds to the total thickness of the cell at a particular location or from an ensemble of locations, how multiple values are treated, whether the thickness is measured under a particular stack pressure, among other conceivable interpretations of “thickness”. In all cases, the measurements are not clear.

295. Moreover, Kim '268 fails to provide a POSITA with any guidance with respect to a mixing ratio of a *weight percentage* of a trinitrile compound to a *weight percentage* of propyl propionate *based on a total weight of the electrolyte*. That is, the solvents of Kim '268 are only disclosed in *volume percentages, based on the total amount of the organic solvent* (Ex. 1008 ¶ [0013], Table 1). Thus, Kim '268

does not contain an *explicit* disclosure of the amount of propyl propionate in the unit of weight percentage “based on a total weight of the electrolyte,” as is required for the claimed Y/Z ratio in independent claim 14 of the ’131 Patent. Kim ’268 also does not contain an *implicit* disclosure of the amount of propyl propionate in the unit of weight percentage based on a total weight of the electrolyte. That is, no information can be taken from Kim ’268 that would allow a POSITA to convert the volume percentages mentioned therein into weight percentages. For example, Kim ’268 provides no information regarding experimental parameters, such as the temperature under which the volume percentages of propyl propionate mentioned therein were determined. Indeed, the density of at least all of the solvents would be necessary for such conversion and the density is not disclosed as a parameter in Kim ’268. Notably, density changes with temperature which also was not provided in Kim ’268. Moreover, the volume would not be conserved when mixing the various components, especially in view of the polar molecules. In addition, at least inasmuch as the lithium salt in the Examples of Kim ’268 is interpreted by the POSITA as being added in solution (i.e., lithium salt dissolved in unknown organic solvent to form 1.15M solution that is then added to the solvent mixtures identified in Kim ’268), the relative weight percentages of propyl propionate and/or any trinitrile in Kim ’268 cannot be determined or controlled. *See* Ex. 1008 Table 1; *see also*,

¶¶ [0023] (“A concentration of the lithium salt may be about 0.1 M to about 2.0 M.”); [0052] (“The lithium salt dissolved in an organic solvent supplies a battery with lithium ions to operate the rechargeable lithium battery, and helps improve transportation of the lithium ions between positive and negative electrodes.”); [0054] (“The lithium salt may be used in a concentration ranging from, for example, about 0.1 M to about 2.0 M. When the lithium salt is included at the above concentration range, an electrolyte may have excellent performance and lithium ion mobility due to optimal electrolyte conductivity and viscosity.”). Thus, Kim ’268 fails to provide a POSITA with any guidance as to a ratio based on weight percentages of components, let alone weight percentages of the components based on a total weight of the electrolyte. Indeed, a POSITA would not be motivated to turn to Kim ’268 from Zhou and/or Hirai at least because the solvents of Zhou are set forth in a relative mass ratio and Kim ’268 only discloses its solvents in *volume percentages*.

296. Additionally, Dr. Lucht’s assertion that “Zhou also cautions the POSITA against using an ‘excessive’ amount of PP for its ‘[] negative effect on the cycle performance, focusing attention on *Y/Z*’ (Ex. 1003 ¶ 209 (citing Ex. 1014 ¶ [0059])) is clearly wrong as the cited portion of Zhou has nothing to do with “excessive PP” as suggested by Dr. Lucht.

297. Accordingly, it is my opinion that Zhou, Hirai, and Kim '268 do not render obvious claims 14-17. I reserve the right to address additional issues with Kim '268 and claims 14-17 individually if this proceeding is instituted.

I. Ground 4A: Zhou, Hirai, and Han Do Not Render Obvious Claim 15

298. Petitioner contends that Zhou, Hirai, and Han render obvious claim 15 of the '131 Patent. For at least the reasons discussed above with respect to Ground 3A, claim 15 are also not unpatentable. It is my opinion that Han does not and cannot cure the deficiencies of Zhou and Hirai. I reserve the right to address additional issues with Han and claim 15 individually if this proceeding is instituted.

J. Ground 4C:¹⁹ Zhou, Hirai, Han, and Kim '268 Do Not Render Obvious Claim 15

299. Petitioner contends that Zhou, Hirai, Han, and Kim '268 render obvious claim 15 of the '131 Patent. For at least the reasons discussed above with respect to Grounds 3A, 3C, and 4A, claim 15 is also not unpatentable. It is my opinion that Han and Kim '268 do not and cannot cure the deficiencies of Zhou and Hirai. I reserve the right to address additional issues with Han and Kim '268 and claim 15 individually if this proceeding is instituted.

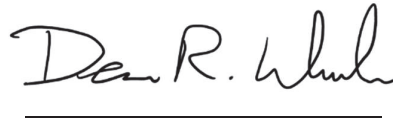
¹⁹ I note that Petitioner does not assert a "Ground 4B."

VII. CONCLUSION

300. In sum, it is my opinion that Grounds 1A, 1B, 1C, 2A, 2B, 2C, 3A, 3C, 4A, and 4C of the Petition do not render Claims 14-17 of the '131 Patent unpatentable as obvious for the reasons I discuss above.

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 August 5, 2025.

A handwritten signature in black ink, appearing to read "Dean R. Wheeler", written over a horizontal line.

Dean R. Wheeler