

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZHUHAI COSMX BATTERY CO., LTD.,
Petitioner

v.

NINGDE AMPEREX TECHNOLOGY LIMITED,
Patent Owner

Case IPR2025-0431
U.S. Patent No. 11,799,131

DECLARATION OF BRETT LUCHT, PH.D.

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5.	[1.4] “wherein, the electrode comprises a current collector,”	49
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b.	[1.6] “an electrode compaction density of the electrode corresponding to the first part with the single-sided coating is D1, and, an electrode compaction density of the electrode corresponding to the second part with the double-sided coating is D2, wherein, about $0.8 \leq D1/D2 \leq$ about 1.2;”	53
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8.	[1.8] “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.”	62
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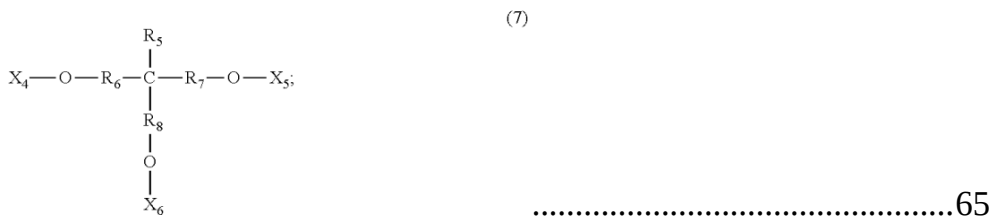
1. [4.1] “The electrochemical device according to claim 1, wherein the dinitrile compound further comprises a compound of Formula (4): 63
- CN—R₁—CN(4); 63
- where R₁ selected from an alkylene group having 1-5 carbon atoms or an alkenylene group having 2-5 carbon atoms.” 63
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1. [6.1] “The electrochemical device according to claim 1, wherein the trinitrile compound comprises a compound of Formula (6) 65

$\text{CN}-(\text{CH}_2)_x-\text{CH}\{(\text{CH}_2)_y-\text{CN}\}-(\text{CH}_2)_z-\text{CN}(6);$ 65

Formula (7)



or a combination thereof, ...65

where in Formula (6), x, y, and z represent an integer from 0 to 5, and x, y, and z are not 0 at the same time; and 65

in Formula (7), R₅ represents hydrogen or an alkyl group having 1-5 carbon atoms, R₆, R₇ and R₈ are each independently an alkylene group having 1-5 carbon atoms, and X₄, X₅ and X₆ are each independently —R₉—CN, in which R₉ represents an alkylene group having 1-5 carbon atoms.” 65

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1. [7.1] “The electrochemical device according to claim 1, wherein X is about 0.01-10 wt %, Y is about 0.01-10 wt%, and a weight percentage Z of the propyl propionate is about 5-50 wt %.” 66

H. Claim 12 68

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6.	[1.5] “a single-sided coating and a double-sided coating; a first part of the current collector is provided with the single-sided coating and a second part of the	

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7.	[1.7] “wherein based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z; wherein, about $0.01 \leq (Y / Z) \leq$ about 0.3;”	108
8.	[1.8] “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.”	108
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where R ₁ selected from an alkylene group having 1-5 carbon atoms or an alkenylene group having 2-5 carbon atoms.”	109
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1. [6.1] “The electrochemical device according to claim 1, wherein the trinitrile compound comprises a compound of Formula (6) 111

CN—(CH₂)_x—CH{(CH₂)_y—CN}—(CH₂)_z—CN(6);.....111

Formula (7)



or a combination thereof, ...111

where in Formula (6), x, y, and z represent an integer from 0 to 5, and x, y, and z are not 0 at the same time; and.....111

in Formula (7), R₅ represents hydrogen or an alkyl group having 1-5 carbon atoms, R₆, R₇ and R₈ are each independently an alkylene group having 1-5 carbon atoms, and X₄, X₅ and X₆ are each independently —R₉—CN, in which R₉ represents an alkylene group having 1-5 carbon atoms” 111

G. Claim 7 112

1. [7.1] “The electrochemical device according to claim 1, wherein X is about 0.01-10 wt %, Y is about 0.01-10 wt%, and a weight percentage Z of the propyl propionate is about 5-50 wt%..” 112

H. Claim 12 112

1. [12.1] “The electrochemical device according to claim 1, wherein the electrolyte further comprising one selected from a group consisting of: a cyclic carbonate ester having a carbon-carbon double bond, a fluorinated chain carbonate ester, a fluorinated cyclic

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2. [3.2] “ $1.2 \text{ g/cm}^3 \leq D2 \leq 1.8 \text{ g/cm}^3$.”	116
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I, Brett Lucht, Ph.D., declare as follows:

I. INTRODUCTION

1. I have been retained by Lee & Hayes, P.C. as a technical expert for Zhuhai CosMX Battery Co., Ltd. (“CosMX” or “Petitioner”), who is the Petitioner in an *Inter Partes* review before the United States Patent and Trademark Office involving U.S. Patent No. 11,799,131 (“the ’131 Patent,” EX1001).

2. Specifically, I have been retained as an independent expert consultant by Petitioner to provide my opinions on the technology claimed in, and the patentability of claims 1-7, 12, and 14-17 (“the challenged claims”) of the ’131 Patent. Although I am being compensated at my usual rate of \$600 per hour for the time I spend on this matter, no part of my compensation depends on the outcome of this proceeding, and I have no financial interest in any of the parties. I have no affiliation with either party in this case besides having been retained as an independent consultant in this matter.

3. I have personal knowledge of the facts and matters in this declaration and believe them to be true.

II. BACKGROUND AND QUALIFICATIONS

4. My *curriculum vitae*, which I understand has been attached as EX1004 in this proceeding, provides full description of my background and technical qualifications, as well as a list of publications that I have authored. In the following

paragraphs I provide a brief overview of my background and qualifications relevant to this matter.

5. I received a BS in Chemistry (1991) from the University of Puget Sound and Ph.D. in Chemistry (1996) from Cornell University and then moved to the University of California, Berkeley for post-doctoral research.

6. I am a Professor at the University of Rhode Island. I arrived at the University of Rhode Island in 1998, was promoted to Associate Professor with tenure in 2002 and Professor in 2006. I have many awards for research and intellectual property at the University of Rhode Island, including the 2016 URI Foundation Scholarly Excellence Award.

7. My research is focused on novel electrolytes and electrolyte electrode interfaces for lithium-ion battery applications which include extending the calendar life, improving low temperature properties, improving the performance of novel high-capacity anodes such as lithium metal or silicon, and improving the performance of high voltage cathode materials. I have received research grants and contracts in support of my research totaling over 14 million dollars. My research has been funded by several United States governmental agencies, including the Department of Energy, National Aeronautics and Space Administration, National Science Foundation, and Department of Defense. My research has also been funded by several companies, including BASF, Samsung, Duracell, and Volkswagen.

8. I have regularly conducted both basic science and applied research and have collaborated extensively with industrial partners. These collaborations have included the development of novel separators and commercial cell design.

9. I have mentored more than 100 students including over 40 graduate students, 30 undergraduate students, 20 postdoctoral fellows, along with several visiting students.

10. I became a Fellow of the Electrochemical Society in 2022 and am currently an Associate Editor for the Journal of Electrochemical Society and was the Chair of the Battery Division of the ECS from 2022-2024.

11. I have published over 190 manuscripts, and my manuscripts have been referenced over 15,000 times. I have also published two book chapters and hold nine patents. I have been an invited or keynote speaker at over 100 companies, universities, national laboratories, and international conferences. My invited and keynote lectures include the International Meeting for Lithium Batteries (Kyoto 2018, Sydney 2022), International Battery Association meeting (Barcelona 2013, France 2016, Korea 2018, Slovenia 2022), Japan Battery Symposium (Kyoto 2019), Munich Battery Discussions (2022), and the Advanced Automotive Battery Conference (Orlando 2012, Atlanta 2014, Detroit 2016, Germany 2018).

12. In the previous five years, I have testified as a witness in the following intellectual property legal matters:

- *Ningde Amperex Tech. Ltd. v. Zhuhai CosMX Battery Co.*, No. 2:22-cv-00232 (E.D. Tex.) (filed Jun. 24, 2022);
- *Advanced Electrolyte Techs. LLC v. eSDi LLC*, No. 1:17-cv-00030 (W.D. Tex.) (filed Jan. 18, 2017);
- *Samsung SDI Co. v. UBE Indus., Ltd.*, No. IPR2018-00611 (PTAB) (filed Feb. 9, 2018);
- *Ascend Performance Materials Operations LLC v. Samsung SDI Co.*, No. IPR2020-00349 (PTAB) (filed Dec. 24, 2019);
- *Maxell, Ltd. v. Amperex Tech. Ltd.*, Nos. 6:21-cv-347-ADA, No. 6:21-cv-1007-ADA (W.D. Tex.) (filed Apr. 8, 2021);
- *Amperex Tech. Ltd. v. Maxell, Ltd.*, No. IPR2021-01440 (PTAB) (filed Sept. 23, 2021);
- *Amperex Tech. Ltd. v. Maxell, Ltd.*, No. IPR2021-01441 (PTAB) (filed Sept. 23, 2021);
- *Amperex Tech. Ltd. v. Maxell, Ltd.*, No. IPR2021-01442 (PTAB) (filed Sept. 23, 2021);
- *Amperex Tech. Ltd. v. Maxell, Ltd.*, No. IPR2021-01443 (PTAB) (filed Sept. 23, 2021);

- *Amperex Tech. Ltd. v. Semiconductor Energy Lab. Co.*, No. 1:23-cv-272-PTG-LRV (E.D. Va); and
- *Zhuhai CosMX Battery Co., Ltd. v. Ningde Amperex Tech. Ltd.*, No. IPR2025-00405 (PTAB) (filed Jan. 10, 2025).

III. MATERIALS CONSIDERED

13. In forming my opinions expressed in this declaration, I have considered, among other things, the following documents. I confirm that to the best of my knowledge the accompanying exhibits are true and accurate copies of what they purport to be, and that an expert in the field would reasonably rely on them to formulate opinions such as those set forth in this Declaration. I understand the documents have been given the following exhibit numbers in this proceeding:

Exhibit No.	Description
1001	U.S. Patent No. 11,799,131 (“the ’131 Patent”)
1002	Prosecution history of U.S. Patent No. 11,799,131 (“the ’131 Patent file history”)
1005	China Patent Application Publication No. CN 106099187A to Zeng et al. (“Zeng”)
1006	Certified English Translation of China Patent Application Publication No. CN 106099187A to Zeng et al. (“Zeng”)
1007	U.S. Patent Application Publication No. 2013/0224535 A1 to Matsuoka et al. (“Matsuoka”)
1008	U.S. Patent Application Publication No. 2017/0288268 to Kim et al. (“Kim”)
1009	Japan Patent Application Publication No. 2009-252349 to Sunose et al. (“Sunose”)

Exhibit No.	Description
1010	Certified English Translation of Japan Patent Application No. 2009-252349 to Sunose et al. (“Sunose”)
1011	China Patent No. 108023117 to Su et al. (“Su”)
1012	Certified English Translation of China Patent No. 108023117 to Su et al. (“Su”)
1013	China Patent Application Publication No. CN 105552439 A to Zhou et al. (“Zhou”)
1014	Certified English Translation of China Patent Application No. CN 105552439 A to Zhou et al. (“Zhou”)
1015	Chinese Patent No. 106848381 (“Hong”) and Certified Translation of Hong
1016	Petition (Paper 1) in <i>Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.</i> , No. IPR2023-00586 (PTAB Feb. 23, 2023)
1017	Decision Denying Institution (Paper 14) in <i>Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.</i> , IPR2023-00586 (PTAB Aug. 18, 2023)
1018	National Library of Medicine PubChem web pages
1019	Millipore Sigma data sheets for ethylene carbonate (EC), propylene carbonate (PC), ethyl propionate (EP), and propyl propionate (PP)
1020	TCI America page for 1,3,6-Hexanetricarbonitrile
1021	Complaint, <i>Ningde Amperex Tech. Ltd. v. Zhuhai CosMX Battery Co.</i> , No. 2:24-cv-00728-JRG (E.D. Tex. Sept. 6, 2024), ECF 1
1023	U.S. Patent Application Publication No. 2017/0324116 A1 to Youichi Ohashi (“Ohashi”)
1024	U.S. Patent Application Publication No. 2016/0294007 A1 to Wang Kefei (“Kefei”)
1025	U.S. Patent Application Publication No. 2017/0069934 A1 to Yun-Hee Kim et al. (“Kim ’934”)
1026	Prosecution history of U.S. Patent No. 11,769,910 (“the ’910 Patent file history”)

Exhibit No.	Description
1027	Alleged Infringement Claim Chart for '131 Patent

In forming my opinions, I have also relied on my education and experience.

IV. RELEVANT LEGAL STANDARDS

14. I am not an attorney. My analysis and opinions are based on my background and expertise in this technical field, as well as the instructions I have been given by counsel for the legal standards relating to patentability.

15. I have been informed by counsel for Petitioner that the following legal principles may apply to analysis of patentability based on 35 U.S.C. §§ 102 for anticipation and 103 for obviousness. I have also been informed that, in an *inter partes* review proceeding such as this one, a patent claim is unpatentable if it is shown by a preponderance of the evidence that the claim would have been anticipated by a prior art patent or publication, or obvious by one or more properly combined prior art patents or publications.

A. Level of Ordinary Skill in the Art

16. I have been instructed to consider patentability of the Challenged Claims through the lens of a person of ordinary skill in the art (“POSITA”) at the time of the claimed priority date of the '131 Patent—September 21, 2018. I am familiar with the level of ordinary skill in the subject matter of the '131 Patent in 2018.

17. Based on my review of the technology, and drawing on my own experience in the field, my analysis below assumes that a POSITA would have had 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. This level of skill is approximate, and more experience would compensate for less formal education, and vice versa. It is consistent with the field identified by the '131 Patent: "the technical field of energy storage technologies, in particular to an electrolyte and an electrochemical device containing the electrolyte." EX1001, 1:18-20.

18. Based on my qualifications discussed above, I qualified at least as a POSITA of the '131 Patent by 2004.

19. My analysis below considers how a POSITA would have understood the references listed above with respect to the Challenged Claims of the '131 Patent.

B. Anticipation

20. I have been informed a patent claim is unpatentable as anticipated under 35 U.S.C. § 102 if every limitation of the claimed invention is found in a single prior art reference--either expressly or required through inherency--as arranged in the claim.

C. Obviousness

21. I have been informed that, even if a single prior art reference does not disclose each and every element of a patent claim, the patent claim is still unpatentable as obvious under 35 U.S.C. § 103. It is my understanding that a claimed invention is unpatentable as obvious over a combination of prior art references if the differences between the claimed invention and the prior art are such that a POSITA would have found the subject matter as a whole obvious.

22. I understand that obviousness is determined by evaluating: (1) the scope and content of the prior art, (2) the differences between the prior art and the claim, (3) the level of ordinary skill in the art, and (4) any secondary considerations of non-obviousness. To establish obviousness based on a combination of the elements disclosed in the prior art, it is my understanding that a challenger must provide a clear articulation of the reason(s) why the claimed invention would have been obvious. I understand this articulation may, but does not necessarily, require record evidence of an explicit teaching, suggestion, or motivation to combine the prior art in the way recited in a patent claim. Rather, prior art may be combined based on an express teaching, suggestion, or motivation from the prior art itself, or from a reasoned explanation of an expert witness or some other rationale.

23. For example, it is my understanding that this articulation can come from a number of rationales, which include but are not limited to (1) combining prior art

elements according to known methods to yield predictable results; (2) simple substitution of one known element for another to obtain predictable results; (3) use of known technique to improve similar devices, methods, or products in the same way; (4) applying a known technique to a known device, method, or product ready for improvement to yield predictable results; (5) choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success, e.g., the combination is “obvious to try”; (6) known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art; and (7) some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed limitation.

24. I further understand that these rationales may be found explicitly or implicitly: (1) in the prior art; (2) in the knowledge of those of ordinary skill in the art that certain references, or disclosures in those references, are of special interest or importance in the field; and/or (3) from the nature of the problem to be solved.

25. Additionally, I understand that the legal determination of the motivation to combine references allows recourse to logic, judgment, and common sense. For example, in order to resist the temptation to read into prior art the teachings of the '131 Patent, the expert should avoid conflating “common sense”

with what appears obvious in hindsight. I understand that if the teachings of a prior art would lead a POSITA to make a modification that would render another prior art device inoperable, then such a modification may not be obvious. I also understand that if a proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there may be no suggestion or motivation to make the proposed modification.

D. Claim Construction

26. Counsel has instructed me that, in this proceeding, the words of a claim are to be given their plain and ordinary meaning, which the meaning understood by a person of ordinary skill in the art after reading the entire patent. This analysis focuses on how the patentee used the claim term in the claims, specification, and prosecution history. Dictionaries or extrinsic sources may assist in determining the plain and ordinary meaning, but extrinsic evidence cannot override a meaning that is unambiguous from the intrinsic evidence.

27. In my opinion, no claim terms require express construction for purposes of evaluating the Grounds in my Declaration. For purposes of my Declaration, and I apply the Patent Owner's position that both claims 1 and 14 read on the same subject matter. I understand that, on January 7, 2025, Patent Owner served contentions in related litigation, including a claim chart alleging infringement of the '131 Patent that equated the elements of claim 14 with claim 1. EX1027. Patent Owner

contended that an electrode having a current collector with both single- and double-sided coating portions satisfied all limitations of claims 1 and 14 of the '131 Patent, without any separate analysis of claim 14. *Id.*, 1-4 (claim 1 analysis), 12-14 (referring to claim 1 for every limitation of claim 14 without more). In my opinion, under Patent Owner's positions, the prior art below art renders obvious the Challenged Claims.

V. TECHNOLOGY BACKGROUND

A. Lithium-Ion Battery Technology

28. Lithium-ion batteries have become a popular power source for portable and other electronic devices because of their high energy density. See EX1006, ¶¶ [0002]-[0006]. A typical lithium-ion battery has a positive electrode (cathode), a negative electrode (anode), a separator, and an electrolyte. The cathode typically comprises a current collector and a layered active material that in the discharged state contains lithium, while the anode typically comprises a current collector with a layered active material capable of receiving lithium ions. The separator prevents physical contact between the cathode and anode, which would cause a short circuit. The electrolyte serves as the medium through which lithium ions travel between the cathode and the anode, and comprises lithium salt, solvent, and optional additives.

29. Lithium-ion batteries operate via a “rocking-chair” mechanism by which the lithium ions move or “rock” back and forth between the cathode and anode as the battery charges and discharges. As shown in Figure 1 below, charging the battery frees lithium ions from the cathode. Lithium ions flow across the electrolyte from the cathode to the anode, becoming intercalated. An external power source drives electrons at the cathode to, likewise, flow through an external circuit into the anode where they undergo a reduction reaction with the intercalated lithium ions, thereby storing an electrochemical potential between the anode and the cathode.

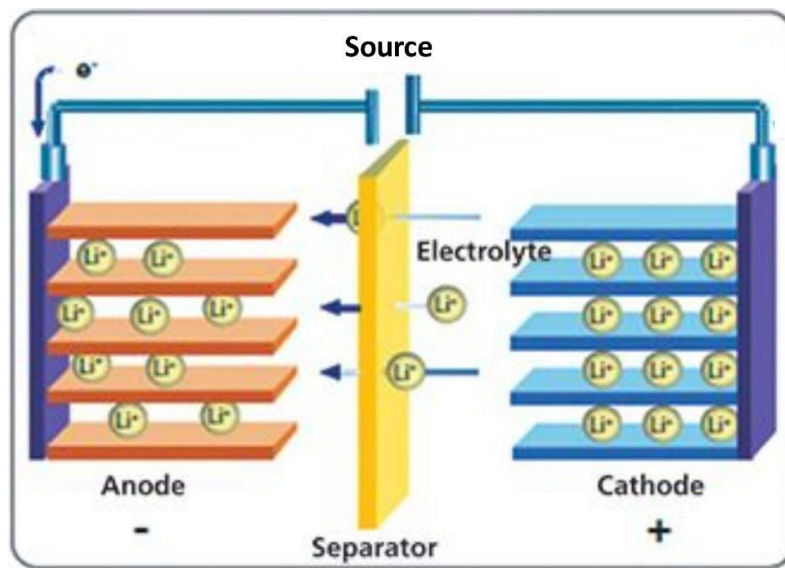


Figure 1: Charging Mechanism for a Lithium-Ion Battery

30. During discharge, the reverse electrochemical process occurs, as shown in Figure 2 below. A load is connected across a circuit between the anode and cathode, where the difference in electrochemical potential drives electrons from the anode to

the cathode to power the load. The deintercalation of lithium ions from the anode frees lithium ions to flow across the electrolyte from the anode to the cathode, where they undergo an oxidation reaction with electrons from the anode.

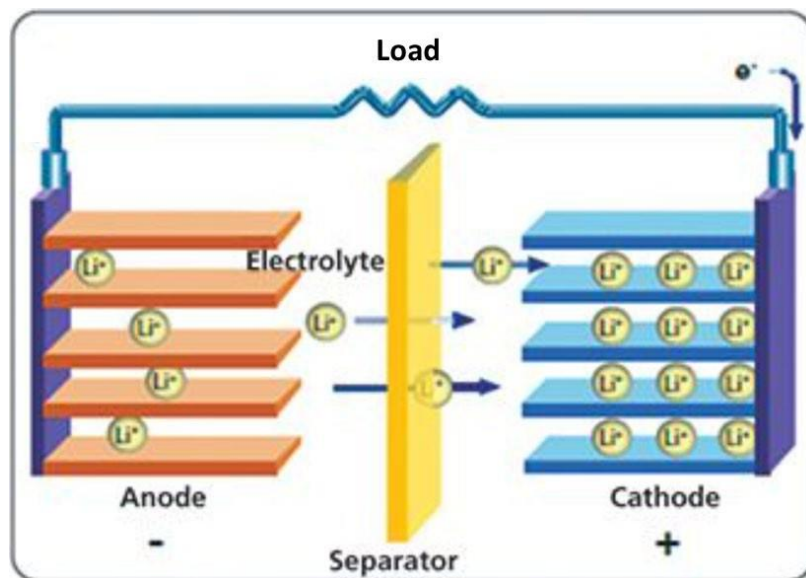


Figure 2: Discharge Mechanism for a Lithium-Ion Battery

31. One charge-discharge sequence is called a cycle.¹ In contrast with primary batteries like alkaline batteries, which cannot be recharged because they irreversibly consume chemical energy in the cathode, lithium-ion and other secondary (rechargeable) batteries can be cycled many times. The discharge reaction in lithium-ion batteries can be reversed by deintercalation of lithium ions to return

¹ An animation showing a charge-discharge cycle is available here:
<https://www.energy.gov/eere/articles/how-does-lithium-ion-battery-work>.

to the anode, thereby returning the battery to its charged composition and structure for additional cycles.

B. Known Dinitrile-Based Electrolytes, Further Containing a Trinitrile Compound and Propyl Propionate, Improved Stability of the SEI Layer

32. The natural phenomenon of solid electrolyte interphase (“SEI”) formation at the electrolyte/electrode interface is an important factor for battery performance and degradation. The SEI layer is a passivating layer formed on the electrode through partial decomposition of the electrolyte, predominantly during the first cycle, that inhibits further electrolyte decomposition from side reactions during later cycles. It is electronically insulating but conductive to lithium ions, allowing lithium ions to pass through it but not electrons. SEI layer formation permanently reduces battery capacity, so it is preferable for the SEI layer to stabilize after the first cycle. But, if the SEI layer is further stressed or degraded during later cycles, it will continue to grow and continue to reduce battery capacity.

33. The demand for higher energy density pushed manufacturers to increase the voltage and capacity of lithium-ion batteries, likewise increasing stress on the SEI layer, making its stability and durability more important. *See, e.g.*, EX1006, ¶¶ [0003]-[0005]; EX1014, ¶¶ [0001]-[0005], [0008]; EX1008, ¶¶ [0001]-[0007]. In my opinion, it was well known in the lithium-ion battery industry before the ’131 patent that electrolytes that contain dinitrile compound (X wt%) and further contain

a trinitrile compound (Y wt%) and PP (Z wt%) made the SEI layer more stable and durable. *See* EX1006, ¶¶ [0037], [0049]; EX1014, ¶¶ [0058], [0059]; EX1008, ¶¶ [0014], [0040], [0090]-[0104] (Table 2), Claim 3. Additionally, in my opinion, the prior art taught that adding a trinitrile compound and PP to dinitrile-based electrolytes improved overall battery performance. *See, e.g.*, EX1008, ¶¶ [0090]-[0091] (Table 2), [0092]-[0104].

VI. THE '131 PATENT

A. Overview

34. In my opinion, the '131 Patent describes lithium-ion batteries having known electrolyte compositions and electrode structures.

- **Electrolyte**

35. Like the prior art, the '131 Patent observes, “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.” EX1001, 1:32-37. The '131 Patent proposes a conventional solution: electrolyte compositions “using a mixture of a dinitrile compound, a trinitrile compound and propyl propionate, [which forms] a firm protective film which is not easily decomposed on the surface of the cathode at a high potential” *Id.*, 1:56-59.

36. The '131 Patent discloses various weight percentages of dinitrile (X), trinitrile (Y), and PP (Z)—based on the total weight of the electrolyte—that purportedly form a durable SEI film. EX1001, 6:1-33. The '131 Patent provides Formulas in which $X+Y$, X/Y , Z , and Y/Z fall within broad ranges, mentioning different upper and lower limits for each throughout the description. *See id.*, Abstract, 6:1-55, 22:63-27:51. The '131 Patent does not express a preference for, or criticality to, any particular set of upper and lower limits for the $X+Y$, X/Y , Z , and Y/Z ranges over any other set.

37. The '131 Patent measured electrolyte performance with three metrics: inhibiting rise in internal resistance, reducing expansion rate, and maintaining voltage capacity during high-temperature storage and cycling (after 200 and 400 cycles). *See* EX1001, 23:32-24:43; *see also id.*, 24:44-32:58.

- **Electrode Coatings**

38. The '131 Patent teaches that the device's "electrode includes a current collector and a coating on the current collector ... [that] includes a single-sided coating, a double-sided coating, or a combination thereof." *Id.*, 20:17-20.

In some embodiments, as shown by an electrode C in FIG. 4 , one surface of a portion of a current collector **1** is coated with a slurry to form a coating **2** and the two opposite surfaces of the other portion of the current collector **1** are coated with a slurry to form a coating **2**. Such coating includes both a single-sided coating and a double-sided coating.

Id., 20:34-40.

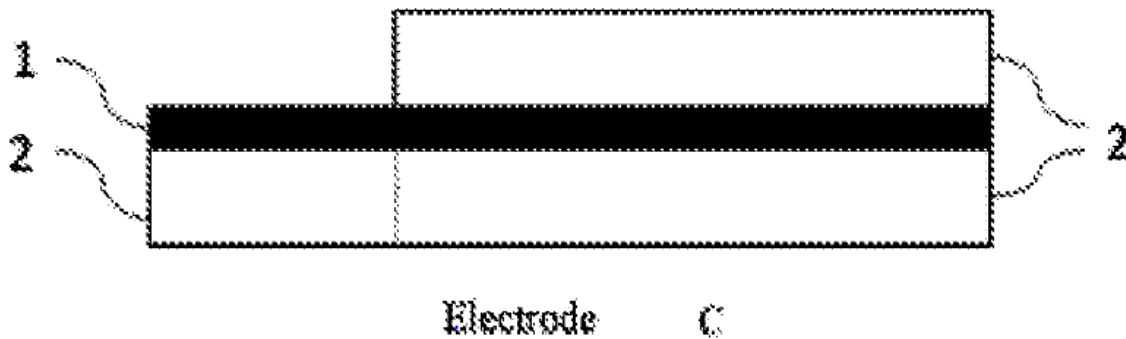


FIG. 4

'131 Patent, FIG. 4

39. The '131 Patent explains that the portion of “the electrode with a single-sided coating has an electrode compaction density D1” while the portion “with a double-sided coating has an electrode compaction density D2,” and the ratio $D1/D2$ falls within various ranges that provide good performance of the electrochemical device. EX1001, 21:10-37. According to the '131 Patent, when “about $0.8 \leq D1/D2 \leq \text{about } 1.2$ ” (the claimed range), “the electrode can obtain good electrical conductivity, which is also important to control the expansion of electrochemical devices,” resulting in “high capacity density and excellent cycle and storage performances.” *Id.*, 21:10-20.

40. In another embodiment, an electrode A has “coating 2 ... only present on one surface of the current collector” and an electrode B has “coating 2... present on two opposite surfaces of the current collector” (FIG. 3). *Id.*, 20:24-33, FIGS. 2, 3 (reproduced at right). This configuration is for “a laminated electrochemical device,” where “the cathode and the anode are usually formed by laminating-shaped electrodes, and there is only a single-sided coating or a double-sided coating on the same electrode.” *Id.*, 20:44-48.

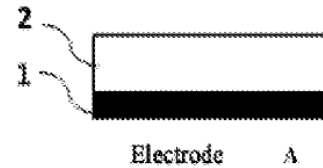


FIG. 2

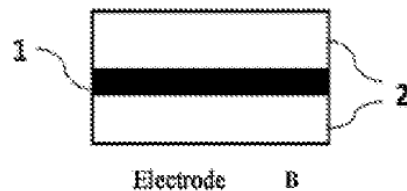


FIG. 3

41. Independent claim 1 recites an electrochemical device incorporating an electrolyte adhering to broad ranges for $X+Y$, X/Y , Z , and Y/Z . An electrode of the device has a single-sided coating portion and a double-sided coating portion in which about $0.8 \leq D1/D2 \leq$ about 1. EX1001, 33:17-53.

1. An electrochemical device, comprising: an electrode; 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 $2 \text{ wt } \% \leq (X+Y) \leq$ about 8 wt %, and

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

the electrode comprises a current collector, a single-sided coating and a double-sided coating; a first part of the current collector is provided with the single-sided coating and a second part of the current collector is provided with the double-sided coating; and an electrode compaction density of the electrode corresponding to the first part with the single-sided coating is D1, and, an electrode compaction density of the electrode corresponding to the second part with the double-sided coating is D2, wherein,

about $0.8 \leq D1/D2 \leq$ about 1.2;

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

about $0.01 \leq (Y/Z) \leq$ 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.

Id., 33:17-53.

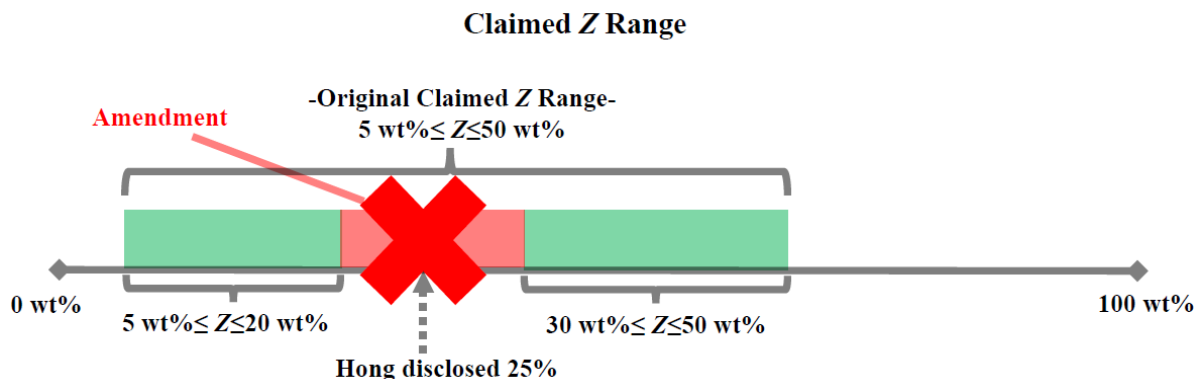
B. Prosecution History

42. I understand that relevant prosecution history includes the prosecution histories of the '131 Patent and U.S. Patent No. 11,769,910 (subject of IPR2025-0405)—which I understand are related as parallel continuation applications stemming from U.S. Patent No. 10,833,363 (subject of IPR2023-00586). In my opinion, both file histories demonstrate that electrochemical devices with electrolytes containing various weight percentages and relationships of dinitrile (X), trinitrile (Y), and PP (Z) were known and unpatentable over prior art. Additionally, the electrode compaction density features (related to *D1* and *D1*) did not persuade the Examiner to allow the '131 Patent. Rather, in both applications, the applicant obtained allowance by selectively amending the limits of the claimed ranges to narrowly avoid the substantially-same parameters taught by the Hong reference (EX1015).

1. The '910 Patent

43. The '910 Patent claims focus on dinitrile-, trinitrile- and PP-based electrolytes, but such compositions were known in the prior art and even cited against them during prosecution. In Application No. 18/076,882, which I understand matured into the '910 Patent, the applicant narrowly overcame Hong anticipation and obviousness rejections by amending the independent claims to exclude 20-30

wt% from the original 5-50 wt% Z range² to avoid Hong's (EX1015) disclosed electrolyte with 25% PP and otherwise satisfying the claim elements:



See, e.g., EX1026, 27-30, 56-77, 194-209.

2. '131 Patent

44. Like prosecution of the '882 Application, and corroborating my opinion, prosecution of the '920 Application (now the '131 Patent) confirmed that electrochemical devices employing dinitrile-, trinitrile- and PP-based electrolytes were known and unpatentable over the prior art.

45. In a first Office Action, the Examiner rejected the pending claims for double patenting and as obvious combinations including Hong (EX1015) and Ohashi (EX1023), relying on Hong for the electrolyte elements and Ohashi for the electrode

² Dependent claim 7 of the '131 Patent also recites the original claimed Z range of the '910 Patent—5 wt%-50 wt%.

compaction density elements. EX1002, 97-112. Ohashi (EX1023) discloses electrode compaction densities ranging from 1 g/cm³-2.2 g/cm³, but the applicant contended that Ohashi's electrode only has a coating on one side. See EX1002, 62-63; EX1023, ¶ [0180].

46. Following an Examiner Interview, EX1002, 50-66, 87, I understand the applicant responded to the Action by amending the independent claims to:

- reduce the upper limit of the claimed $X+Y$ range from 11 wt% to 8 wt%;
- reduce the upper limit of the claimed X/Y range from 8 to 6;
- add a previously unrecited range for Y/Z ;
- add a listing of permissible trinitrile compounds; and
- clarify that $D1$ and $D2$ are compaction densities of the first and second parts of the electrode having a single-sided coating and a double-sided coating, respectively.

Id., 73-95.

47. Regarding the electrolyte aspects, the applicant argued that the specific Hong Examples relied upon in the Action had trinitriles “not included within the Markush group specified in [the independent] claims[.]” *Id.*, 91. The applicant also argued that Hong did not expressly disclose the weight percentages of trinitrile (Y), PP (Z), or the entire organic solvent based on the total weight of the electrolyte. *Id.*, 92.

48. Regarding the electrode features, I understand the applicant argued “*neither Hong nor Ohashi disclose or suggest the configuration where a *first part* of the current collector is coated on a *single side*, while a *second part* of the current collector is coated on ***both sides***.” *Id.*, 90 (emphasis in original).³ According to the applicant, the claims were allowable because “Hong discloses electrodes formed by applying active material coating to ***both sides*** of the current collector, while Ohashi discloses electrodes formed by applying active material coating to ***only one side*** of the current collector.” EX1002, 90 (emphasis in original).*

49. I understand the Examiner then allowed the application, focusing on the amended electrolyte component ranges—not the electrolyte structure—in the Examiner’s reasons for allowance:

[W]hile the applied references disclose a battery electrolyte having a number of organic, compound constituents at various combinations and ratios with the electrode structure, as set forth in the claims, none disclose nor render obvious the electrolyte having the *specific* organic compounds at the *explicit* amounts and ratios as set forth in the claims and electrode structure as set forth in the claim.

Id., 30. Notably, the Examiner did not find the electrode structure alone patentable. This is consistent with the Examiner’s summary of the interview that “Applicant

³ Unless otherwise specified, all emphasis is added in my Declaration.

argues prior art does not disclose *amended ranges of materials & compounds* of proposed amendments and compares this to what the prior art reference(s) show,” which “Examiner stated this appears persuasive.” *Id.*, 51.

3. My proposed prior art and obviousness opinions undercut the Examiner’s reasons for allowance

50. In my opinion, the prior art and obviousness arguments I propose in this Declaration undercut the Examiner’s reason for allowing the ’131 Patent claims. While this will become clear in the Grounds below, I explain why briefly here:

- **Zeng**

51. Zeng discloses the specific organic compounds in the explicit amounts and ratios recited in the Challenged Claims. Specifically, Zeng Embodiments 4 and 6 disclose electrolytes including both a dinitrile compound and a trinitrile compound (1,3,6-hexanetricarbonitrile) permitted by the recited Markush group. *Infra* Sections IX.A, IX.B.

52. Zeng also discloses PP in the claimed amount as a component of a dinitrile- and trinitrile-based electrolyte. Addressing the applicant’s criticism of Hong, Zeng discloses the weight percentage of the organic solvent plus LiPF₆ based on the total weight of the electrolyte. This is because Embodiments 4 and 6 provide the weight percentages of all remaining additives, including the weight percentage Y of the trinitrile, based on the total weight of the electrolyte. *Infra* Section IX.A

(11.7 wt% and 11.5 wt% respectively). Thus, the total weight of the organic solvent portion is simply $100 \text{ wt\%} - 11.7 \text{ wt\%} = 88.3 \text{ wt\%}$ in Embodiment 4 and $100 \text{ wt\%} - 11.5 \text{ wt\%} = 88.5 \text{ wt\%}$ in Embodiment 6. *Infra* Section IXI.A. And because PP starts at 20 wt% in the solvent portion before adding LiPF_6 and the remaining additives, Zeng suggests or renders obvious that PP constitutes less than $20\% \times 88.3\% = 17.66 \text{ wt\%}$ and less than $20\% \times 88.5\% = 17.70 \text{ wt\%}$ based on the total electrolytes of Embodiments 4 and 6, respectively. *Infra* Section IX.A. Moreover, in my opinion, PP could not be diluted—i.e., Z could not be reduced—to value that would violate the broadly-claimed Y/Z range without reducing the weight of the solvent to an atypical and unworkable portion of the total electrolyte inconsistent with Zeng’s disclosure and lithium-ion batteries generally. *Infra* Section IX.B.7.

- **Zhou**

53. In addition to Zeng, it is my opinion that Zhou discloses, or at least renders obvious, the specific compounds, ranges, and relationships recited in the Challenged Claims. Zhou Example 8, for example, teaches an electrolyte that satisfies the claims but for having the carboxylic acid ester ethyl acetate (EA), instead of PP, at 16.56 wt% based on the total weight of the electrolyte. *Infra* Section XIII.A. Nevertheless, Zhou discloses, and it my opinion, that PP is one of just a few well-known and predictable substitutes for EA that would also provide high ion-transport in the electrolyte. Thus, in my opinion, it would have been obvious to

replace EA with PP in Example 8, arriving at the claimed subject matter. *Infra* Sections IX.A, IX.B.3.

- **Matsuoka and Kim**

54. In my opinion, although PP was well-known as an electrolyte performance enhancer, Matsuoka and Kim provide particularly specific motivation to consider and modify the amount of PP, as well as the ratio of trinitrile to PP (Y/Z), to improve lithium-ion battery performance. *Infra* Sections XI, XII. Matsuoka discloses preferred weight percentage ranges based on the total electrolyte for non-nitrile electrolyte components—including PP, which Matsuoka touts for improving the SEI layer. *Infra* Section XI. In addition, it is my opinion that it would have been obvious to simply select Matsuoka's preferred weight for PP as the weight percentage Z in Zeng's Embodiment 4 and 6 electrolytes. *Infra* Section XI.

- **Sunose and Su**

55. In my opinion, Sunose and Su disclose electrodes having the claimed single- and double-sided compaction densities purportedly absent in Hong and Ohashi. *Infra* Sections IX.B.6, X. Sunose describes single- and double-side-coated cathodes having the claimed compaction density ratios that exhibited good adhesion and reduced electrode breakage during rolling or compaction. A POSITA would have been motivated to use Sunose's advantageous cathodes in Zeng's and Zhou's electrochemical devices—which are broad in terms of electrode implementation

details. *Infra* Section IX.B.6. Su discloses anodes with single- and double-sided coating portions having the claimed compaction density ratios and teaches that this configuration increases energy density of the battery. *Infra* Section X.

- **My proposed prior art and obviousness opinions were not substantively evaluated**

56. As I understand it, Zeng, Zhou, and Su were not meaningfully evaluated and applied during original prosecution. Rather, in the '882 Application, the applicant only provided English Abstracts of Zeng and Zhou in a prolix information Disclosure Statement. See EX1002, 184-191. Su was not cited in the '882 Application, and the applicant only provided an English abstract of Su with an Information Disclosure Statement during prosecution of the '910 Patent. EX1026, 83, 384. But the Abstracts alone do not have enough information, and the information I rely on in my opinions, to determine whether the '131 Patent claims would have been obvious over of the complete references. Zeng, Zhou, and Su were not substantively evaluated on the record, such as used in a rejection or otherwise analyzed. Similarly, Kim was cited in an Information Disclosure Statement but not substantively evaluated and/or applied. EX1002, 186; EX1026, 383. Matsuoka and Sunose were not cited at all in original prosecution.

C. IPR2023-00586 ('363 Patent IPR)

57. I understand that CosMX filed an *inter partes* review Petition challenging the '363 Patent using Hong as an anticipatory reference. EX1016.

58. Based on my review, the Patent Trial and Appeal Board denied institution of the '363 Patent IPR petition because it relied on the Hong anticipation ground and made three assumptions for which the panel found insufficient evidentiary support:

(1) the total volume of the liquid components does not meaningfully change after mixing, (2) the solid components do not meaningfully contribute to the total volume of the electrolyte, and (3) Hong's tricyanophosphate and tricyanophosphite compounds are liquids at room temperature with a density of 0.60 g/cm³.

See EX1017, 10-12; EX1016.

59. My opinions regarding validity of the '131 Patent, however, do not require any of the assumptions required by the Hong reference, in part, because I rely on obviousness rather than anticipation the '363 Patent IPR Petition.

VII. CLAIM CONSTRUCTION

60. I have been informed that, in IPR, claim terms receive their ordinary and customary meaning as understood by a POSITA at the time of the invention.

61. I have been instructed that, for the purposes of this Petition, all claim terms should receive their plain and ordinary meaning in the context of the

specification. It is my opinion that no claim terms require express construction for purposes of evaluating my positions.

62. For purposes of my declaration, I apply Patent Owner's positions that both claims 1 and 14 read on the same subject matter. I understand that, on January 7, 2025, Patent Owner served contentions in related litigation, including a claim chart alleging infringement of the '131 Patent that equated the elements of claim 14 with claim 1. EX1027, 12-14. Patent Owner contended that an electrode having a current collector with both single- and double-sided coating portions satisfied all limitations of claims 1 and 14 of the '131 Patent, without any separate analysis of claim 14. *Id.*, 1-4 (claim 1 analysis), 12-14 (referring to claim 1 for every limitation of claim 14 without more). In my opinion, under Patent Owner's positions, Petitioner's art renders obvious the Challenged Claims.

VIII. SUMMARY OF GROUNDS OF INVALIDITY

63. After analyzing the '131 Patent, prosecution history, prior art, and other documents identified above, and relying on the knowledge of a POSITA, it is my opinion that the Challenged Claims are rendered obvious as follows:

Ground ⁴		Claims	References
Zeng Grounds			
1	A	1, 2, 4-7, 12, 14, 15, 17	• China Patent Application Publication No. CN 106099187A (“Zeng”, EX1005). • Japan Patent Application No. 2009-252349 (“Sunose”, EX1009).
	B		• Zeng • Sunose • U.S. Patent Application Publication No. 2013/0224535 A1 (“Matsuoka”, EX1007).
	C		• Zeng; Zeng/Matsuoka • Sunose • U.S. Patent Application Publication No. 2017/0288268 A1 (“Kim”, EX1008).
2	A	3, 16	• Zeng • Sunose • China Patent No. 108023117 (“Su”, EX1011).
	B		• Zeng • Sunose • Matsuoka • Su

⁴ In my Declaration, the A Grounds correspond to the base reference combinations: **Ground 1:** Zeng and Sunose; **Ground 2:** Zeng, Sunose, and Su; **Ground 3:** Zhou and Sunose; and **Ground 4:** Zhou, Sunose, and Su. The B Grounds add Matsuoka to the base combinations (for Zeng Grounds 1 and 2 only). The C Grounds further add Kim to the base combinations.

Ground ⁴		Claims	References
	C		• Zeng; Zeng/Matsuoka • Sunose • Su • Kim
3	A	1, 2, 4-7, 12, 14, 15, 17	• China Patent Application Publication No. CN 105552439 A (“Zhou”, EX1014). • Sunose
	C		• Zhou • Sunose • Kim
4	A	3, 16	• Zhou • Sunose • Su
	C		• Zhou • Sunose • Su • Kim

A. Zeng

64. I understand that Zeng is a China Patent Application filed on July 13, 2016 and published November 9, 2016. EX1006, 1. I have been instructed to assume that Zeng legally qualifies as prior art to the '131 Patent.

65. Zeng discloses “a wide-temperature-range homogenous non-aqueous electrolyte solution” based on a dinitrile compound (adiponitrile) for lithium-ion batteries. EX 1006, Abstract. In addition to adiponitrile, Zeng Embodiments 4 and 6 further contain a trinitrile compound (1,3,6-hexane tricyanide (“HTCN”)) and PP.

EX1006, ¶¶ [0045]-[0049]. These electrolytes have 20 wt% PP before mixing the inorganic lithium salt, and Zeng discloses the total weight of the solvent and lithium salt in the total electrolyte by providing the weight percentages of all additives based on the total weight of the electrolyte. *Id.*

B. Sunose

66. Sunose is a Japan Patent Application filed in 2008 and published in 2009. EX1010, 1. I have been instructed to assume that Sunose legally qualifies as prior art to the '131 Patent.

67. Sunose discloses a cathode configuration for rolled electrodes in which the active layer coating has a single-sided portion and a double-sided portion with respective compaction densities, falling in the scope of claims 13 and 14. *See, e.g.*, EX1010, ¶¶ [0005], [0007]-[0010], [0012], [0013], [0024], [0029]-[0033], [0040]. Sunose teaches that having a packing ratio M/N of 0.7 to 1.0 between the single- and double-sided portions uniformly distributes pressure during the rolling process, improving adhesion of the electrode layers and reducing breakage. *Id.*, ¶¶ [0016], [0017], [0027], [0028], [0042].

C. Su

68. Su is a China Patent Application filed November 30, 2017 and published May 11, 2018. EX1012, 1. I have been instructed that Su qualifies legally as prior art to the '131 Patent.

69. Su describes a lithium-ion battery with high energy density in which the cathode and anode electrode plates having portions with single- and double-sided coatings. EX1012, Abstract, ¶¶ [0001], [0008]-[0013], [0027]. In multiple Su Examples, a ratio of the compaction density of the single sided portion to the compaction density of the double-sided portion—which falls between 1.2 g/cc and 1.8 g/cm³—is 1.0. *Id.*, ¶¶ [0050]-[0067].

D. Matsuoka

70. Matsuoka is a U.S. Patent Application Publication filed in 2011 and published in 2013. EX1007, 1. I have been instructed to assume that Matsuoka legally qualifies as prior art to the '131 Patent.

71. Matsuoka discloses electrolytes for lithium-ion batteries that contain one or more nitrile additives and one or more non-nitrile additives—including PP—to improve the durability of the SEI layer formed on the electrode surface. EX1007, Abstract, ¶¶ [0015], [0022], [0035], [0036], [0038], [0040], [0044], [0056]-[0061]. Matsuoka lists PP isomers as suitable additives with LUMO and HOMO energies falling in or near the most-preferred ranges. *Id.*, ¶¶ [0038], [0040]. Matsuoka observes that non-nitrile additives having LUMO (Lowest Unoccupied Molecular Orbital) and HOMO (Highest Occupied Molecular Orbital) energy levels in certain ranges are particularly helpful for improving SEI layer durability. *Id.*, ¶¶ [0015], [0022], [0036], [0039].

E. Kim

72. Kim is a U.S. Patent Application filed in 2016 and published October 5, 2017. EX1008, 1. I have been instructed to assume that Kim legally qualifies as prior art to the '131 Patent.

73. Kim discloses electrolyte compositions for lithium-ion batteries. EX1008, Abstract. Kim Examples 1 and 2 contain a dinitrile (succinonitrile, SN), a trinitrile (1,3,6-hexane tricyanide, HTC�), and differing amounts of PP. *Id.*, ¶¶ [0090]-[0091] (Table 1). Batteries with the Example 1 and 2 electrolytes—the electrolytes that included a dinitrile, a trinitrile, and PP—outperformed Kim's Comparative Examples that lacked either the trinitrile or PP in battery recovery capacity and reduction in thickness expansion during high temperature storage and cycling. *Id.*, ¶¶ [0090]-[0103], FIGS. 3-6. In my opinion, Kim highlights that importance of the combination of a dinitrile, a trinitrile and PP—and varying the relative amounts of trinitrile and PP in the electrolyte—to improve battery performance.

F. Zhou

74. Zhou is a China Patent Application filed on December 16, 2015 and published May 4, 2016. EX1013; EX1014, 1. I have been instructed to assume that Zhou legally qualifies as prior art to the '131 Patent.

75. As I discuss below, Zhou describes “a fast-charging lithium-ion battery electrolyte, which is composed of a solvent, a lithium salt, and an additive, wherein the solvent includes a mixture of two or more of a low-boiling-point linear carbonate and a linear carboxylic acid ester[.]” EX1014, Abstract. Zhou Example 8 is a dinitrile-based (adiponitrile) electrolyte further containing a trinitrile compound (1,3,6-hexane trinitrile, HTC�) and ethyl acetate (EA)—a disclosed alternative linear carboxylic acid ester that can be substituted with PP. *Id.*, ¶¶ [0011], [0047].

IX. GROUND 1A: ZENG AND SUNOSE RENDER OBVIOUS CLAIMS 1, 2, 4-7, 12, 14, 15, AND 17

A. Overview of Zeng—Electrolyte Containing X, Y, and Z in the Claimed Relationships

76. Zeng discloses dinitrile- and trinitrile-based electrolytes containing X, Y, and Z in the claimed ranges and relationships. Zeng Embodiments 4 and 6 have 20 wt% PP *before* adding LiPF₆ and additives, suggesting or rendering obvious that the total electrolyte has less than 20 wt% PP (and certainly more than 5 wt%). EX1001, claim 7. In my opinion, Zeng Embodiments 4 and 6 render obvious the Challenged Claims. *See* EX1006, ¶¶ [0045]-[0049].

77. Zeng describes embodiments of “a wide-temperature-range homogenous non-aqueous electrolyte solution that has good lithium ion transport properties, electrode plate wettability, and interfacial compatibility.” EX1006, ¶ [0009]. In addition to a dinitrile compound, Zeng’s electrolytes have:

- a “multi-component homogenous mixed solvent” (including PP);
- fluoroethylene carbonate (FEC);
- dinitrile compounds, adiponitrile (ADN) and 1,2-bis(2-cyanoethoxy)ethane (DENE); and
- at least one second nitrile “compound having the structure shown in structural formula I” which can include trinitriles.

EX1006, ¶¶ [0011]-[0018], [0024].

78. Zeng teaches the roles that each of these components plays in the electrolyte. For example, Zeng explains that FEC is used for its “good film-forming properties and resistance to oxidation[,]” which “ensures good high-voltage cycling performance of the battery without seriously affecting the high-temperature performance of the battery[.]” *Id.*, ¶ [0028].

79. Further, the dinitrile (i.e., ADN and DENE) and the trinitrile compounds complement each other at different temperatures. Dinitriles “stabilize the structure of the positive electrode material, compensating for the high-temperature battery gas production problem caused by the FEC,” *id.*, ¶ [0034], which “improv[es] the high-temperature performance of the battery,” *id.*, ¶ [0029]. In complementary fashion, the trinitrile “has better solubility in the electrolyte solution, without the problem of precipitation at low temperatures”—improving low-

temperature performance. *Id.*, ¶ [0030]; *see also id.*, Abstract (“storage for a long period of time ... below -30°C”), ¶¶ [0038], [0045] (Table 1).

80. Zeng Embodiments 4 and 6 both have less than 20 wt% PP in the total electrolyte. Zeng Embodiments 4 and 6 contain PP as a solvent component, ADN and DENE as *dinitrile* compounds, and 1,3,6-hexanetricarbonitrile T4 (HTCN)—a *trinitrile*—as the Formula I nitrile. EX1006, ¶¶ [0024], [0044]-[0049]. In both Embodiments, “ethylene carbonate, propylene carbonate, diethyl carbonate, fluorobenzene, ethyl propionate, and PP are mixed at a *mass* ratio of EC:PC:DEC:FB:EP:PP = 25:10:30:5:10:20[.]” *Id.*, ¶ [0037]⁵; *see also id.*, ¶ [0044]. “[T]hen, lithium hexafluorophosphate of a concentration of 1.0 mol/L is slowly added to the mixed solution,”⁶ followed by further additives in certain weight percentages. EX1006, ¶ [0037].

⁵ Unless otherwise specified, emphasis is added.

⁶ In my opinion, a POSITA would understand this to mean adding solid LiPF₆ to the specified EC:PC:DEC:FB:EP:PP solvent mixture to reach a concentration of 1.0 mol/L. While LiPF₆ is commercially available premixed in different solvents to different concentrations, Zeng already discloses an EC:PC:DEC:FB:EP:PP solvent mixture for its electrolytes. In such cases, it is standard practice to mix LiPF₆ in the

81. Thus, Zeng Embodiments 4 and 6 both have less than 20 wt% PP in the total electrolyte. This is because the solvent mixture has 20 wt% PP before LiPF_6 and the remaining components are added, scaling down PP's weight proportion below 20 wt% in the total electrolyte.

82. For Zeng Embodiments 4 and 6, to this base electrolyte mixture,

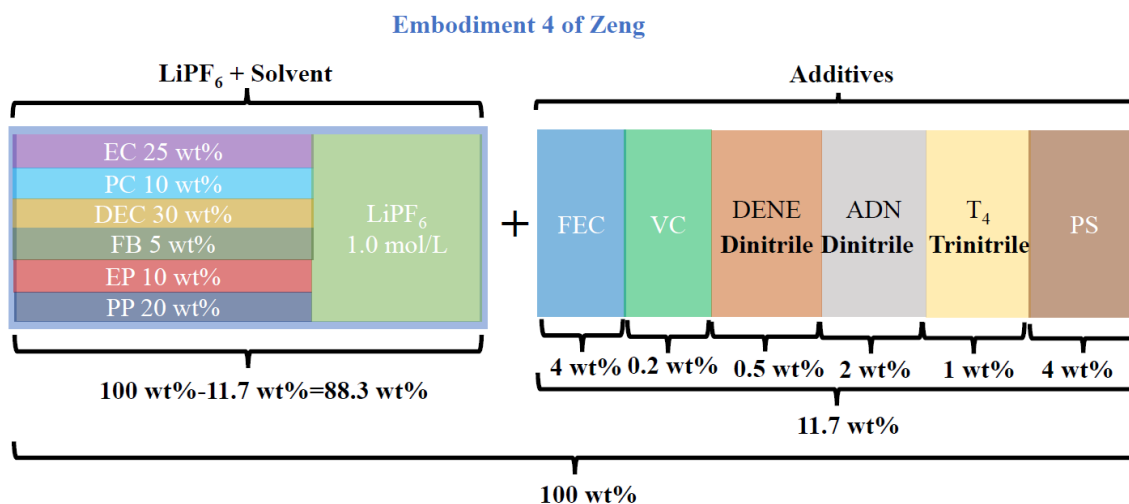
specified solvent mixture to a target concentration—usually around 1 mol/L—not add LiPF_6 , premixed in some second solvent mixture, to the first solvent mixture. See, e.g., EX1023, ¶¶ [0237], [0245], [0255] (Solvent components were mixed “to form a non-aqueous solvent, *into which was dissolved LiPF₆, so as to be 1.2 M*, and were added [various additives by wt%][.]”); EX1024, ¶ [0048] (“stir and mix homogeneously organic solvents according to certain ratios to obtain a solvent for electrolyte solutions” and then “[s]lowly add a lithium salt, and when the lithium salt is dissolved, add additives ...”) EX1025, ¶ [0090] (“An electrolyte was prepared by mixing ethylene carbonate and ethyl methyl carbonate ... to prepare a non-aqueous organic solvent and *dissolving 1.0 M LiPF₆*, hexane tricyanide (1,3,6 or 1,2,6-Hexanetricarbonitrile) (HTCN), ...”). Aside from rendering the ultimate concentration of LiPF_6 uncertain, adding some premixed solution of LiPF_6 would disrupt the carefully-crafted solvent and additive weight percentages central to Zeng's invention.

the following are added on the basis of the *total weight of the electrolyte solution*: 4 wt% of fluoroethylene carbonate (FEC), 2 wt% of adiponitrile (ADN) ... , 0.5 wt% of 1,2-bis(2-cyanoethoxy)ethane (DENE), 0.2 wt% of vinylene carbonate (VC), and 4.0 wt% of 1,3-propane sultone[.]

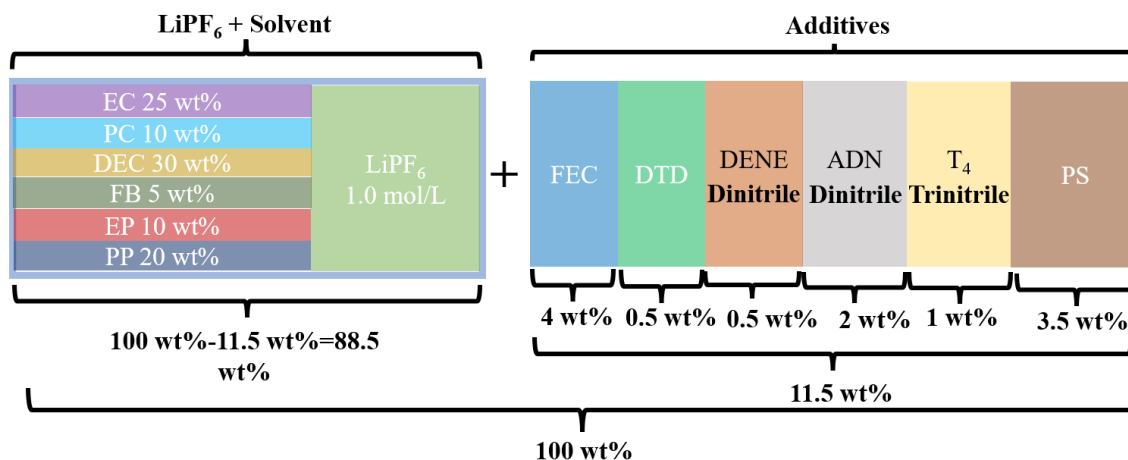
Id.; see also *id.*, ¶¶ [0044]-[0049].

83. Embodiment 4 also contained the *trinitrile* 1,3,6-hexanetricarbonitrile (HTCN, “T4”) as the Formula I nitrile. *Id.*, ¶¶ [0044]-[0049] (Table 1). Embodiment 6 was identical to Embodiment 4 except that it swapped VC for 0.5 wt% ethylene sulfate (“DTD”) and had slightly less PS at 3.5 wt%. *Id.*, ¶ [0046].

84. Thus, Zeng Embodiments 4 and 6 have the following compositions:



Embodiment 6 of Zeng



85. **Weight percentage of ADN and DENE (*dinitrile*) in the total electrolyte:** ADN is a *dinitrile*, as claimed, because it has two nitrile (-CN) groups in its structure, with the molecular structure NC-CH₂-CH₂-CH₂-CH₂-CN. EX1018, 1, 318. DENE is also a *dinitrile*, as claimed, with the molecular structure NC-CH₂-CH₂-O-CH₂-CH₂-O-CH₂-CH₂-CN. *Id.*, 318. As illustrated above, in both Embodiments 4 and 6, ADN and DENE have a combined weight ratio (the claimed X) of 2 wt%+0.5 wt%=2.5 wt% based on a total weight the total electrolyte.

86. **Weight percentage HTCN (*trinitrile*) in the total electrolyte:** HTCN is a *trinitrile*, as claimed, because it has three -CN groups with the molecular formula C₉H₁₁N₃. EX1018, 100; EX1020. As illustrated above, in both Embodiments 4 and 6, HTCN has a weight ratio (the claimed Y) of 1 wt% in the total electrolyte.

87. **Weight percentage PP in the total electrolyte:** As explained, Embodiments 4 and 6 had 20 wt% PP relative to the solvent mixture before adding

lithium hexafluoride and the remaining additives. The upper limit of the weight percentage range for PP can be found by assuming a hypothetical case where LiPF_6 has zero weight. Unlike the Hong reference, and as reflected in the Figure above, Zeng tells us that the additives alone must total 11.7 wt% and 11.5 wt% based on the total weight of the electrolytes of Embodiments 4 and 6, respectively. Thus, PP would have a weight percentage in the total electrolyte of $88.3\% \times (20 / (25 + 10 + 30 + 5 + 10 + 20)) = 17.66$ wt% in Embodiment 4 and of $88.5\% \times (20 / (25 + 10 + 30 + 5 + 10 + 20)) = 17.70$ wt% in Embodiment 6, assuming LiPF_6 has zero weight. But since any amount of LiPF_6 has weight, it is my opinion that a POSITA would know or find obvious that PP constitutes less than 17.66 wt% and less than 17.70 wt% based on the total weight of the electrolytes of Embodiments 4 and 6, respectively, with LiPF_6 added.

88. Moreover, as I explain below in Ground 1A where applicable, 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.

89. As one example, diluting PP (i.e., reducing Z) to 5 wt% of the total electrolyte (low end of Z range recited in claim 7) would make the solvent just 25 wt% of the total electrolyte: $5 \text{ wt\% PP (total electrolyte)} \times 100 \text{ wt\% (total solvent)} / 20 \text{ wt\% PP (total solvent)} = 25 \text{ wt\% solvent (total electrolyte)}$. This flips the notion

of solvent-based electrolyte in which “additives” and LiPF_6 are dissolved into a solvent.

90. Zeng specifies that the additives are 11.7 wt% and 11.5 wt% based on the total weight of the Embodiment 4 and 6 electrolytes. Thus, the total weight percentage of solvent plus additives is:

- **Embodiment 4:** 11.5 wt% additives (total electrolyte) + 25 wt% solvent (total electrolyte) = 36.5 wt% additives plus solvent (total electrolyte); and
- **Embodiment 6:** 11.7 wt% additives (total electrolyte) + 25 wt% solvent (total electrolyte) = 36.7 wt% additives plus solvent (total electrolyte).

91. This leaves $100 \text{ wt\%} - 36.5 \text{ wt\%} = 63.5 \text{ wt\%}$ LiPF_6 in Embodiment 4 and $100 \text{ wt\%} - 36.7 \text{ wt\%} = 63.3 \text{ wt\%}$ LiPF_6 in Embodiment 6, based on the total weight of the electrolytes.

92. Assuming, for example, that LiPF_6 is about 60 wt% of the total electrolyte, there would be 600 g of LiPF_6 in 1 kg of electrolyte and 400 g of solvent in 1 kg of electrolyte. Since the densities of the solvents are approximately 1 g/ml at room temperature (around 25°C)—the temperature at which such electrolyte compositions are typically prepared—there would be approximately 400 ml of the solvents in 1 kg of electrolyte. See, e.g., EX1019, 2 (density of EC is 1.321 g/ml),

12 (density of PC is 1.204 g/ml), 20 (density of EP is 0.888 g/ml), 29 (density of PP is 0.881 g/ml), 36 (density of DEC is 0.975 g/ml), 45 (density of FB is 1.024 g/ml). Since the molecular weight of LiPF_6 is 151.9 g/mol, this would correspond to a molality of approximately $600 \text{ g} / 151.9 \text{ g/mol} = 3.95 \text{ mol/kg}$ solution of LiPF_6 . See EX1018, 126 (density of LiPF_6). With the displacement caused by adding LiPF_6 , the molarity would be similar but slightly less than the molality. And this is nearly *four times* the very typical concentration (1.0 mol/L) specified by Zeng and completely atypical for lithium-ion battery electrolytes. Thus, in my opinion, and as explained below in the Grounds, Zeng renders obvious the claimed electrolyte compositions.

93. In summary, the claimed X, Y, and Z have the following values in Zeng's Embodiments:

Embodiment	X (Weight Percentage ADN and DENE in Total Electrolyte)	Y (Weight Percentage 1,3,6-hexanetricarbonitrile in Total Electrolyte)	Z (Weight Percentage PP in Total Electrolyte)
4	2.5 wt%	1 wt%	< 17.66 wt%
6	2.5 wt%	1 wt%	< 17.70 wt%

Zeng Embodiments 4 and 6 improved high-voltage cycling performance of lithium-ion batteries, as shown in Table 1 of Zeng. In particular, the batteries using the Embodiment 4 and 6 electrolytes exhibited increased capacity retention rate than the Comparative Examples. EX1006, ¶¶ [0045]-[0047].

- **Rationale to Implement Embodiments 4 and 6 of Zeng**

94. Each 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.

95. In my opinion, Zeng teaches, suggests, and motivates a POSITA to use the Embodiment 4 and 6 electrolytes. First, the Embodiments 4 and 6 batteries significantly outperformed the Comparative Example batteries in capacity retention after 500 cycles. See EX1006, ¶¶ [0045]-[0047]. Moreover, outside of Embodiments 2 and 5, Embodiment 6 had the best capacity retention at 91.6%. *Id.* In my opinion, these superlative results would have motivated the POSITA to implement at least Embodiments 4 and 6.

96. At the very least, in my opinion, it would have been “obvious to try” Zeng Embodiments 4 and 6.

97. **Recognized need in the art:** Zeng observes a market need for “high-energy density lithium-ion batteries” driven by “consumer terminals demand[ing] ever-higher energy density from batteries[.]” EX1006, ¶ [0003]. Conventionally, energy density was “improved primarily by selecting high-capacity, highly compact positive and negative electrode active materials and increasing the battery charge cut-off voltage.” *Id.* This reduced stability of the positive electrode, so FEC was added to resist the resulting oxidation of the electrolyte. *Id.*, ¶ [0005]. But FEC is

prone to decomposition at high temperatures, increasing battery expansion and internal resistance. *Id.* The industry then added organic nitriles to stabilize the electrode structure but, among other issues, organic nitriles have poor solubility in electrolyte solutions, limiting cycling performance and low-temperature performance. *Id.*, ¶ [0006]. Zeng thus sought a well-rounded dinitrile- and trinitrile-based “electrolyte solution that can remain homogeneous 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.” *Id.*, ¶ [0008].

98. **Finite number of identified, predictable solutions:** Zeng only discloses nine electrolyte solutions (Embodiments 1-9), and all demonstrating better capacity retention over 500 cycles and low-temperature performance than the Comparative Examples. EX1006, ¶¶ [0044]-[0047] (Table 1). 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%). *Id.* In my opinion, these performances would have motivated a POSITA to implement Embodiments 4 and 6.

99. **Reasonable expectation of success:** All Zeng’s Embodiments were successfully tested in batteries and outperformed the Comparative Examples. EX1006, ¶¶ [0036]-[0053]. According to Zeng, the Embodiments successfully showed “that the addition of FEC and ADN to the electrolyte solution improves the

high-voltage cycling performance of the lithium-ion battery, and with the increase in added amounts of FEC and ADN, the capacity retention rate of the lithium-ion battery at 500 cycles of high voltage increases incrementally.” *Id.*, ¶ [0050]. Zeng also provides detailed preparation instructions to make the electrolytes of the Embodiments. *See id.*, ¶¶ [0036]-[0049]. In my opinion, these teachings would have given a POSITA a reasonable expectation of success in implementing Embodiments 4 and 6.

B. Independent Claim 1

1. [1.pre]⁷ “An electrochemical device, comprising”

100. As discussed, in my opinion, the Zeng Embodiments 4 and 6 electrolytes each renders the Challenged Claims unpatentable. EX1006, ¶¶ [0046], [0049]; *see also* Section IX.A. Zeng Embodiment 4 and 6 electrolytes were used in a lithium-ion secondary battery (an electrochemical device) as claimed. *Id.*, ¶¶ [0028]-[0034].

101. Accordingly, in my opinion, Zeng discloses or suggests element [1.pre].

⁷ In my declaration, I use bracketed reference numerals to identify respective Challenged Claim Elements of the ’131 Patent.

2. [1.1] “an electrode; and”

102. In my opinion, Zeng discloses or suggests this element. As I explained in Section IX.A, Zeng’s Embodiments 4 and 6 were used in a lithium-ion secondary battery, which is an electrochemical device that comprises electrodes, as claimed. See EX1006, ¶¶ [0028]-[0034], [0052], [0053].

103. Accordingly, in my opinion, Zeng discloses or suggests element [1.1].

3. [1.2] “an electrolyte comprising a dinitrile compound, a trinitrile compound, and propyl propionate;”

104. In my opinion, Zeng discloses or suggests this element. As discussed in Section IX.A, Zeng’s Embodiments 4 and 6 electrolytes contain *a dinitrile compound* (ADN, DENE), *a trinitrile compound* (HTCN), and *PP*, as claimed. EX1018, 1, 318; EX1020; EX1006, ¶¶ [0037], [0044]-[0049] (Table 1).

105. Accordingly, in my opinion, Zeng discloses or suggests element [1.2].

4. [1.3] “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 wt % $\leq$ (X+Y) $\leq$ about 8 wt %, and about $0.1\leq$ (X/Y) $\leq$ about 6;”

106. In my opinion, Zeng renders obvious this element. As I explained above, X and Y and have the following values in Zeng’s total electrolyte:

Embodiment	X	Y	X + Y	X/Y
4	2.5 wt%	1 wt%	3.5 wt%	2.5
6	2.5 wt%	1 wt%	3.5 wt%	2.5

Supra Section IX.A. Thus, in both Embodiments, $X+Y=2.5\text{ wt\%}+1\text{ wt\%}=3.5\text{ wt\%}$, falling in the claimed range of about 2 wt% to about 8 wt%; and X/Y equals 2.5, falling in the claimed range of about 0.1 to about 6.

107. Accordingly, in my opinion, Zeng discloses or suggests element [1.3].

5. [1.4] “wherein, the electrode comprises a current collector,”

108. In my opinion, Zeng discloses or suggests this element. Zeng discloses electrolytes for “ensuring good high-voltage performance of a lithium-ion battery.” EX1006, Abstract. Batteries using the Embodiment 4 and 6 electrolytes were tested for performance. *Id.*, ¶¶ [0036]-[0053]. A lithium-ion battery, by definition, is an electrochemical device having a cathode that comprises a current collector and an anode that comprises a current collector. *See also* EX1010, Abstract, ¶ [0021].

109. Accordingly, in my opinion, Zeng discloses or suggests element [1.4].

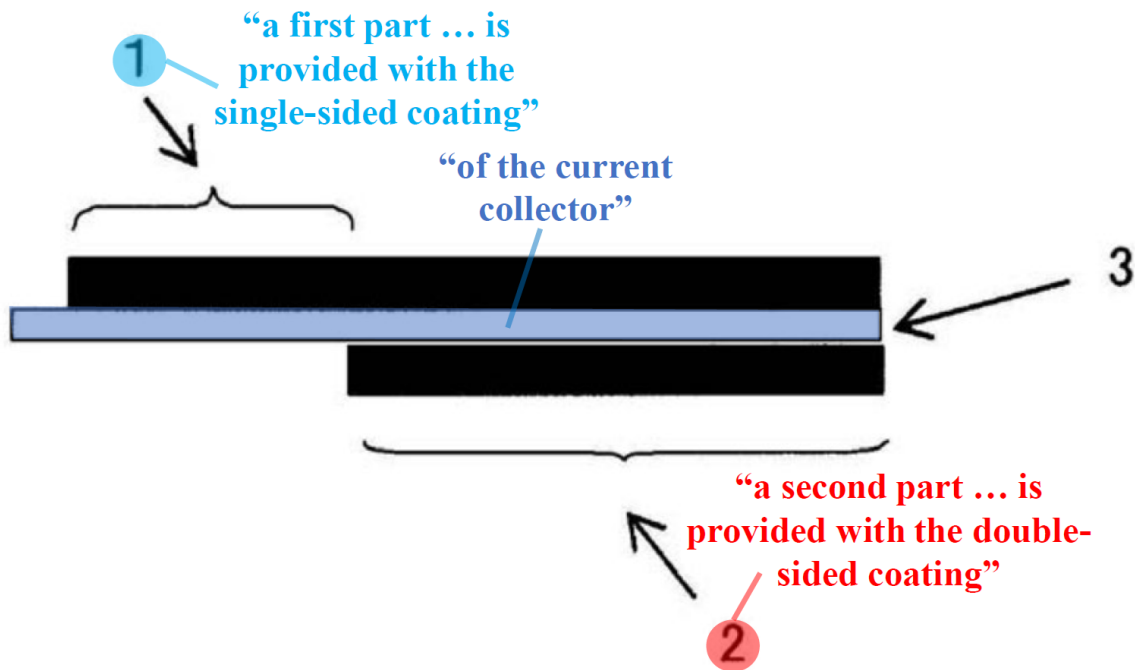
6. Elements [1.5], [1.6]

110. Zeng focuses on electrolyte compositions, not detailed electrode structures. But, Sunose discloses a lithium-ion battery with a cathode having single- and double-sided coating portions on its current collector, as claimed. In my opinion, a POSITA would have found it obvious to modify Zeng’s battery based on Sunose to arrive at the claimed subject matter.

- a. [1.5]: “a single-sided coating and a double-sided coating; a first part of the current collector is provided with the single-sided coating and a second part of the current collector is provided with the double-sided coating; and”

111. As highlighted in Figure 2 below, Sunose discloses a positive electrode (cathode) with *a single-sided coating and a double-sided coating; a first part (single-side coating part 1) of the current collector (current collector 3) is provided with the single-sided coating and a second part (double-sided coated part 2) of the current collector (current collector 3) is provided with the double-sided coating*, as claimed.

EX1010, ¶¶ [0005], [0007]-[0010], [0012], [0013], [0024].



Sunose, FIG. 2*⁸

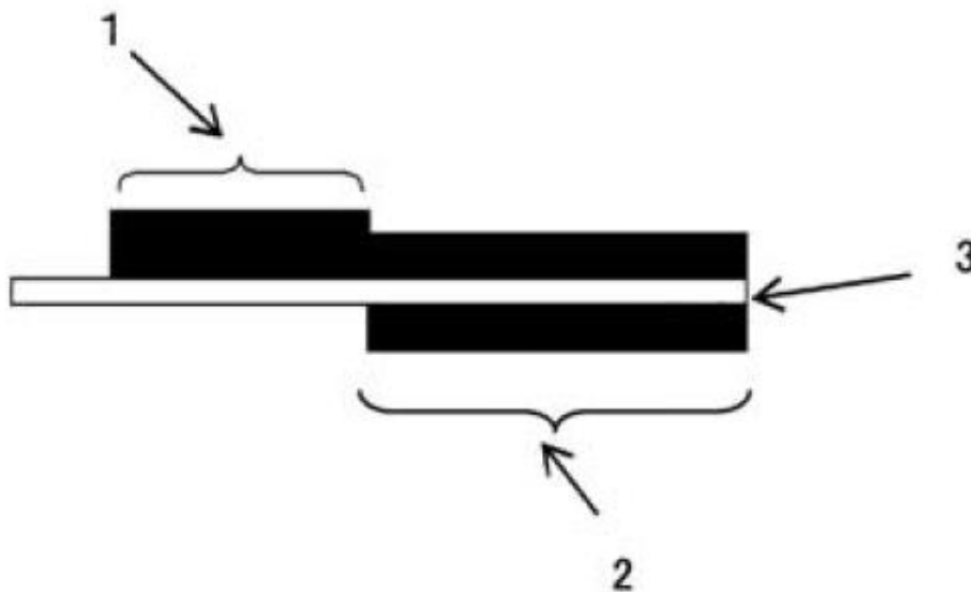
112. As shown, Sunose’s electrode has “[a] single-sided active material layer portion [1], wherein the active material layer is formed only on a single side of the current collector [3]” and “[a] two-sided active material portion [2]” with an active material layer formed on both sides of the current collector 3. EX1010, ¶[0007]. Accordingly, in my opinion, Sunose discloses or suggests Element [1.5].

113. Sunose notes that while one rolling setting might provide the right compaction density and adhesion for the single-sided portion, that same setting can

⁸ I identify annotated or otherwise modified figures from the Exhibits with an “*”.

excessively load the thicker double-sided portion, weakening the electrode and increasing crack rate and breakage. EX1010, ¶¶ [0010], [0012]. Sunose addressed this problem by making the pre-compaction thickness of the single-sided coating greater than that of each coating of the double-sided coating portion, as seen in Figure 1 below. *Id.*, Abstract, [0011]-[0017], [0022], [0023], [0025]-[0029].

[FIG. 1]



Sunose, FIG. 1

114. Then, Sunose rolls the electrode to control the resulting ratio N/M of the packing density N ($D2$) of the double-sided coating portion to the packing density M ($D1$) of the single-sided coating portion to fall between 0.7 and 1.0. *See, e.g., id.*, ¶¶ [0012]-[0017], [0021]-[0023], [0041]-[0043]. In this manner, the rolling

process applies uniform pressure across both portions of the electrode, improving overall adhesion while avoiding breakage (peeling and/or cracking) of the electrode.

See, e.g., id., ¶¶ [0018], [0021], [0022], [0028], [0042], [0044].

- b. [1.6] “an electrode compaction density of the electrode corresponding to the first part with the single-sided coating is $D1$, and, an electrode compaction density of the electrode corresponding to the second part with the double-sided coating is $D2$, wherein, about $0.8 \leq D1/D2 \leq \text{about } 1.2$;”

115. In my opinion, Sunose discloses this element. At least Sunose’s electrode plates of Examples 2-4 satisfy element [1.6], having single- and double-sided electrode compaction densities $D1$, $D2$ (packing densities) falling within the claimed ranges, as shown in the table below:

Example	$D1$ (g/cm ³) (M)	$D2$ (g/cm ³) (N) ⁹	$D1/D2$
2	5.0	4.0	1.25
3	4.4	4.0	1.1
4	4.0	4.0	1.0

EX1010, ¶¶ [0031], [0032], [0033], [0040], Table 1.

⁹ Sunose’s N, M respectively correspond to claimed $D2$, $D1$ because the former is density for the double-sided coated portion of the electrode and the latter is the packing density for the single-sided coating portion. *See, e.g.*, EX1010,

116. In my opinion, Sunose’s densities are the claimed *compaction densities of the electrode* because they are “the packing density of the active material layer on which coating has been applied.” EX1010, ¶ [0021]. This matches the density calculation in the ’131 Patent specification, which excludes the weight and thickness of the current collector to isolate the active layer density. *See* EX1001, 20:54-64.

117. For the density N, “rolling was performed using a roll press machine to obtain a density of the active material layer on the two-side coated portion,” resulting in the density values N in the Examples. EX1010, ¶ [0031]. Likewise, for the density M, “a density of the active material layer on the single-side coated portion,” resulting in the density values M of the Examples. *Id.*; *see also id.*, ¶¶ [0032]-[0037], [0041]-[0044] (“active material density”). The “rolling process” ... “roll[s] the electrodes that have been coated and dried in the manufacturing process at high density,” thereby compacting the electrodes. *Id.*, ¶ [0006]; *see also id.*, ¶¶ [0007], [0008], [0012]-[0016].

118. All Sunose Examples have a “packing” density D2 of 4.0 g/cm³ for the double-sided portion 2, and Examples 2 through 4 respectively have packing densities D1 of 5.0, 4.4, and 4.0 g/cm³. EX1010, ¶¶ [0029]-[0033], [0040]. This

¶¶ [0014], [0021], [0041], Table 1. That is, D1/D2 in the ’131 Patent is the same as M/N in Sunose.

results in a ratio $D1/D2$ of 1.25, 1.1, and 1.0 for Examples 2-4 of Sunose, respectively. The ratios for Examples 3 and 4 fall within the claimed range. Furthermore, in my opinion, a POSITA would reasonably consider Example 2's ratio 1.25, which falls within the '131 Patent's 10% tolerance, to be "*about 1.2*," as claimed. Indeed, I note that the '131 Patent states that "about" covers "minor variations" including "less than or equal to $\pm 10\%$ of the stated value" EX1001, 4:12-31. Thus, Sunose Example 2's ratio of 1.25 constitutes less than a 10% "minor variation"—within $(1.25-1.2)/1.2=4.2\%$ of the claimed range. *Id.*

119. Accordingly, in my opinion, Sunose discloses or suggests element [1.6].

c. Rationale to combine Zeng and Sunose

120. In my opinion, a POSITA would have been motivated, with a reasonable expectation of success, to configure Zeng's cathode according to the cathode configuration described in Sunose, resulting in Elements [1.5] and [1.6]. That is, a POSITA would have found it obvious to make the pre-rolling thickness of the single-sided coating greater than the thickness of each of the layers forming the double-sided layer—as shown in Figure 1 of Sunose—and rolled the electrode to achieve the resulting compaction density ratio N/M taught by Sunose.

- **Analogous art**

121. In my opinion, Sunose is analogous art to Zeng because it falls in the same field of endeavor—lithium-ion secondary batteries, including those employing non-aqueous electrolytes. *See* EX1010, Abstract, ¶¶ [0001]-[0011], [0043], [Claim 3]. Zeng seeks to improve performance of lithium-ion batteries, which have electrode assemblies, by describing advantageous electrolyte compositions. EX1006, ¶¶ [0001]-[0006]; *see also* EX1001, 20:41-53, 23:24-28. Sunose's electrode assembly, including its compaction density properties, improves battery performance by increasing adhesion of the electrode layers while mitigating breakage of the electrode plate during rolling. EX1010, ¶¶ [0010], [0012], [0017], [0018], [0021], [0024].

- **Teaching, suggestion, motivation**

122. In my opinion, the teachings of Zeng and Sunose would have motivated a POSITA to use Sunose's electrode assembly configuration in Zeng Embodiment 4 and 6 batteries in which the single-sided coating is made thicker than each double-sided coating portion (as shown in Figure 1) and the electrode is rolled to Sunose's disclosed compaction density ratio N/M of the double- and single-sided coated portions.

123. **Electrode assembly implementation details:** Zeng focuses on electrolyte compositions and omits configuration details for the electrode assembly.

Thus, in my opinion, a POSITA reading Zeng would have looked to other references, like Sunose, for electrode assembly implementation details. The need to use some rolled electrode configuration in Zeng's batteries would have prompted a POSITA adopt Sunose's electrode configuration.

124. **Maximizing electrode area:** Sunose's teaches a particularly advantageous rolled electrode configuration that maximizes electrode area, thereby increasing battery capacity and performance. Specifically, Sunose teaches that electrode configuration, "wherein the positive electrode plate and negative electrode plate are wound with a separator interposed therebetween," serves "to maximize the electrode area" in two ways. EX1010, ¶ [0004]. First, Sunose's spiral design permits more electrode surface area within a given space, increasing capacity. *Id.*, ¶ [0004]. Second, rolling the electrode assembly exposes surfaces of the innermost and outermost ends of the rolled current collector, "increas[ing] the effective electrode area, thereby improving battery performance." *Id.*, ¶ [0005]. In my opinion, industry pressure, noted by Zeng and Sunose, to increase battery capacity and performance would have motivated the POSITA to use Sunose's electrode design to increase electrode surface area for a given form factor.

125. **Improving adhesion and reducing breakage:** In my opinion, the desire to reduce electrode breakage and improve electrode adhesion would have enticed a POSITA to use Sunose's electrode configuration in Zeng—i.e., arrange the

single- and double-sided electrode coating thicknesses according to Figure 1 and rolling the electrode to Sunose's disclosed compaction densities to reduce electrode breakage and improve adhesion.

126. According to Sunose, one rolling setting might provide the right compaction density and adhesion for the single-sided portion, but that same setting excessively loads the thicker double-sided portion, weakening the electrode and increasing crack rate and breakage. EX1010, ¶¶ [0010], [0012]. Sunose addressed this problem by making the pre-rolling thickness of the single-sided coating greater than that of each coating of the double-sided coating portion and rolling the electrode to control the ratio N/M of the packing density N ($D2$) of the double-sided coating portion to the packing density M ($D1$) of the single-sided coating portion to fall between 0.7 and 1.0. *Id.*, ¶¶ [0016], [0017], [0027], [0028], [0042], [0043], FIG. 1. Then, Sunose's rolling process applies uniform pressure across both portions of the electrode, improving overall adhesion while avoiding breakage. *Id.*, ¶ [0042], [0044].

- **Reasonable expectation of success**

127. In my opinion, a POSITA would have had a reasonable expectation of success using Sunose's rolled electrode configuration in Zeng's batteries. Zeng does not disclose any physical requirements for its high-voltage (4.4V) lithium-ion batteries, which are broadly intended for "the digital, energy storage, power, and

military aerospace fields.” EX1006, ¶ [0002]; *see also id.*, ¶ [0035]. Likewise, Sunose generally intends its rolled electrode configuration for “consumer electronic devices,” so in my opinion, the POSITA would have reasonably expected Sunose’s electrode configuration to work in Zeng’s batteries. EX1010, ¶ [0002].

7. [1.7] “wherein based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z; wherein, about $0.01 \leq (Y/Z) \leq$ about 0.3;”

128. In my opinion, Zeng discloses or suggests this element. The claimed Y and Z have the following values in Zeng:

Embodiment	Y	Z	Y/Z
4	1 wt%	<17.66 wt%	>0.057
6	1 wt%	<17.70 wt%	>0.056

Supra Section IX.A. Thus, 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.

129. Furthermore, in my opinion, a POSITA would have known or found obvious that both Zeng Embodiments’ Y/Z ratios fall below the claimed upper limit of 0.3. With Y=1 wt%, achieving a Y/Z ratio of 0.3 or more would require Z to be 3.33 wt% or less in the total electrolyte. But diluting PP (i.e., reducing Z) from 20 wt% of the solvent to 3.33 wt% of the total electrolyte would make the solvent just 16.65 wt% of the total electrolyte: 3.33 wt% PP (total electrolyte) x 100 wt% (total

solvent) / 20 wt% PP (total solvent) = 16.65 wt% solvent (total electrolyte). This reverses the notion of solvent-based electrolyte in which “additives” and LiPF_6 are dissolved in a solvent.

130. Zeng specifies that the additives are 11.7 wt% and 11.5 wt% based on the total weight of the Embodiment 4 and 6 electrolytes. Thus, the total weight percentage of solvent plus additives is:

- **Embodiment 4:** 11.5 wt% additives (total electrolyte) + 16.65 wt% solvent (total electrolyte) = 28.15 wt% additives plus solvent (total electrolyte); and
- **Embodiment 6:** 11.7 wt% additives (total electrolyte) + 16.65 wt% solvent (total electrolyte) = 28.35 wt% additives plus solvent (total electrolyte).

131. This leaves $100 \text{ wt\%} - 28.15 \text{ wt\%} = 71.85 \text{ wt\%}$ LiPF_6 in Embodiment 4 and $100 \text{ wt\%} - 28.35 \text{ wt\%} = 71.65 \text{ wt\%}$ LiPF_6 in Embodiment 6, based on the total weight of the electrolytes.

132. Assuming, for example, that LiPF_6 is about 70 wt% of the total electrolyte, there would be 700 g of LiPF_6 in 1 kg of electrolyte and 300 g of solvent in 1 kg of electrolyte. Since the densities of the solvents are approximately 1 g/ml at room temperature (around 25°C)—the temperature at which such electrolyte compositions are typically prepared—there would be approximately 300 ml of the

solvents in 1 kg of electrolyte. *See, e.g.*, EX1019, 2 (density of EC is 1.321 g/ml), 12 (density of PC is 1.204 g/ml), 20 (density of EP is 0.888 g/ml), 29 (density of PP is 0.881 g/ml), 36 (density of DEC is 0.975 g/ml), 45 (density of FB is 1.024 g/ml). Since the molecular weight of LiPF_6 is 151.9 g/mol, this would correspond to a molality of approximately $700 \text{ g} / 151.9 \text{ g/mol} = 4.61 \text{ mol/kg}$ solution of LiPF_6 . *See* EX1018, 126 (density of LiPF_6). With the displacement caused by adding LiPF_6 , the molarity would be similar but slightly less than the molality. And this is nearly *five times* the very typical concentration (1.0 mol/L) specified by Zeng, and completely atypical for lithium-ion battery electrolytes.

133. Accordingly, in my opinion Zeng Embodiments 4 and 6 render obvious a Y/Z range falling entirely within the claimed range—greater than 0.01 (0.057 and 0.056) and certainly less than 0.3.

134. Accordingly, in my opinion, Zeng discloses or suggests element [1.7].

8. [1.8] “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.”

135. In my opinion, Zeng discloses or suggests this element. Zeng Embodiments 4 and 6 both have 1,3,6-hexanetricarbonitrile (HTCN) as the claimed *trinitrile compound*. EX1006, ¶¶ [0046], [0049]; *supra* Section IX.A.

C. Claim 2

1. [2.1] “The electrochemical device according to claim 1, wherein the electrode is a cathode, and $3.5 \text{ g/cm}^3 \leq D2 \leq 4.3 \text{ g/cm}^3$.”

136. In my opinion, the Zeng/Sunose combination includes this element. As I explained above, Zeng’s lithium-ion battery includes electrodes—a *cathode* and an anode. Section IX.B.2; EX1006, Abstract, ¶¶ [0028]-[0034], [0052]-[0053]. Sunose focuses on the configuration of the *cathode* (positive electrode). *See, e.g.*, EX1001, ¶¶ [0011]; [0029]-[0040]. Moreover, as explained above in Section IX.B.6.b, all four Sunose Examples had a packing density $N(D2)$ of 4 g/cm^3 for the double-sided coating portion of the current collector, falling in the claimed range of $3.5 \text{ g/cm}^3 \leq D2 \leq 4.3 \text{ g/cm}^3$. EX1010, ¶¶ [0031]-[0033], [0040].

137. Sunose discloses using its compaction density ratio N/M (D2/D1) for the active material coatings of the “*positive* electrode current collector [4]” of Figure 1—the current collector of the claimed *cathode*. *Id.*, ¶¶ [0024], [0029]; *see also id.*, ¶¶ [0021], [0023]-[0034]. The N and M compaction density parameters for all four Sunose Examples pertained to the “positive electrode” coating. *Id.*, ¶¶ [0029]-[0034], [0040]-[0041] (Table 1). Thus, for the reasons discussed above in Section IX.B.6.c, it is my opinion that a POSITA would have incorporated Sunose’s electrode configuration for the *cathode* of Zeng’s Embodiments.

138. Accordingly, in my opinion, Zeng and Sunose render obvious Claim 2.

D. Claim 4

1. [4.1] “The electrochemical device according to claim 1, wherein the dinitrile compound further comprises a compound of Formula (4):



where R₁ selected from an alkylene group having 1-5 carbon atoms or an alkenylene group having 2-5 carbon atoms.”

139. In my opinion, Zeng discloses or suggests Claim 4. In Embodiments 4 and 6, Zeng’s *dinitrile compound* includes adiponitrile. EX1006, ¶¶ [0029]-[0030]. The structural formula for adiponitrile is CN(CH₂)₄CN, so the alkylene group R₁ (i.e., (CH₂)₄ or CH₂-CH₂-CH₂-CH₂) has four carbon atoms. *See* EX1018, 1. The ’131 Patent identifies adiponitrile specifically as one of the compounds satisfying

Formula [4]. EX1001, 7:13-19 (The '131 Patent Specification identifying adiponitrile specifically as a compound of Formula [4]).

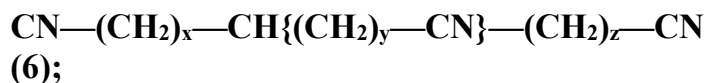
E. Claim 5

1. [5.1] “The electrochemical device according to claim 1, wherein the dinitrile compound is one selected from the group consisting of butanedinitrile, glutaronitrile, adiponitrile, 1,5-dicyanopentane, 1,6-dicyanohexane, 1,7-dicyanoheptane, 1,8-dicyanooctane, 1,9-dicyanononane, 1,10-dicyanodecane, 1,12-dicyanododecane, tetramethylbutanedinitrile, 2-methylglutaronitrile, 2,4-dimethylglutaronitrile, 2,2,4,4-tetramethylglutaronitrile, 1,4-dicyanopentane, 2,6-dicyanoheptane, 2,7-dicyanooctane, 2,8-dicyanononane, 1,6-dicyanodecane, 1,2-dicyanobenzene, 1,3-dicyanobenzene, 1,4-dicyanobenzene, 3,5-dioxapimelonitrile, 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.”

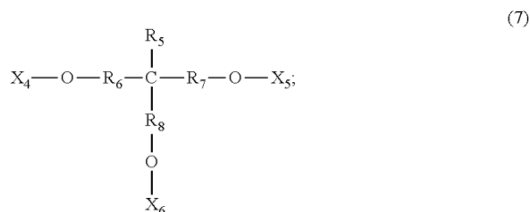
140. In my opinion, Zeng discloses or suggests Claim 5. As I explained above, Zeng Embodiments 4 and 6 have *adiponitrile* (ADN) and *ethylene glycol bis(2-cyanoethyl)* (DENE) as the claimed *dinitrile compound*, both recited in claim 5. EX1006, ¶¶ [0029]-[0030]; *supra* Section IX.A.

F. Claim 6

1. [6.1] “The electrochemical device according to claim 1, wherein the trinitrile compound comprises a compound of Formula (6)



Formula (7)



or a combination thereof,

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

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

141. In my opinion, Zeng discloses or suggests this element. As discussed, Zeng Embodiments 4 and 6 both have 1,3,6-hexanetricarbonitrile (HTCN)—both recited in claim 5— as the claimed *trinitrile compound*. EX1006, ¶¶ [0046], [0049]; *supra* Section IX.A. HTCN has the structural formula NC-CH₂-CH(CN)-CH₂-CH₂-CH₂-CN and thus satisfies claimed Formula (6) where x=1, y=0, z=3, meeting the

claimed requirement that “*x, y, and z represent an integer from 0 to 5, and x, y, and z are not 0 at the same time[.]*” See also EX1018, 100-103; EX1020. Confirming this, after introducing Formula (6), the ’131 Patent specification provides a list of compliant trinitriles that includes 1,3,6-hexanetricarbonitrile. EX1001, 7:41-8:27.

G. Claim 7

1. [7.1] “The electrochemical device according to claim 1, wherein X is about 0.01-10 wt %, Y is about 0.01-10 wt%, and a weight percentage Z of the propyl propionate is about 5-50 wt %.”

142. In my opinion, Zeng discloses or suggests this element. As I explained above, X, Y, and Z have the following values in Zeng, falling within the claimed ranges for X, Y, and Z:

Embodiment	X (Weight Percentage ADN and DENE)	Y (Weight Percentage HTC�)	Z (Weight Percentage PP)
4	2.5 wt%	1 wt%	< 17.66 wt%
6	2.5 wt%	1 wt%	< 17.70 wt%

Supra Section IX.A.

143. I note that a POSITA would find it obvious that both Embodiments have Z values well above 5 wt% (low end of claimed Z range) of the total electrolyte. Diluting PP (i.e., reducing Z) to 5 wt% of the total electrolyte would make the solvent just 25 wt% of the total electrolyte: 5 wt% PP (total electrolyte) x 100 wt% (total solvent) / 20 wt% PP (total solvent) = 25 wt% solvent (total electrolyte). This flips

the notion of solvent-based electrolyte in which “additives” and LiPF_6 are dissolved into a solvent.

144. Zeng specifies that the additives are 11.7 wt% and 11.5 wt% based on the total weight of the Embodiment 4 and 6 electrolytes. Thus, the total weight percentage of solvent plus additives is:

- **Embodiment 4:** 11.5 wt% additives (total electrolyte) + 25 wt% solvent (total electrolyte) = 36.5 wt% additives plus solvent (total electrolyte); and
- **Embodiment 6:** 11.7 wt% additives (total electrolyte) + 25 wt% solvent (total electrolyte) = 36.7 wt% additives plus solvent (total electrolyte).

145. This leaves $100 \text{ wt\%} - 36.5 \text{ wt\%} = 63.5 \text{ wt\%}$ LiPF_6 in Embodiment 4 and $100 \text{ wt\%} - 36.7 \text{ wt\%} = 63.3 \text{ wt\%}$ LiPF_6 in Embodiment 6, based on the total weight of the electrolytes.

146. Assuming, for example, that LiPF_6 is about 60 wt% of the total electrolyte, there would be 600 g of LiPF_6 in 1 kg of electrolyte and 400 g of solvent in 1 kg of electrolyte. Since the densities of the solvents are approximately 1 g/ml at room temperature (around 25°C)—the temperature at which such electrolyte compositions are typically prepared—there would be approximately 400 ml of the solvents in 1 kg of electrolyte. See, e.g., EX1019, 2 (density of EC is 1.321 g/ml),

12 (density of PC is 1.204 g/ml), 20 (density of EP is 0.888 g/ml), 29 (density of PP is 0.881 g/ml), 36 (density of DEC is 0.975 g/ml), 45 (density of FB is 1.024 g/ml). Since the molecular weight of LiPF_6 is 151.9 g/mol, this would correspond to a molality of approximately $600 \text{ g} / 151.9 \text{ g/mol} = 3.95 \text{ mol/kg}$ solution of LiPF_6 . See EX1018, 126 (density of LiPF_6). With the displacement caused by adding LiPF_6 , the molarity would be similar but slightly less than the molality. And this is nearly *four times* the very typical concentration (1.0 mol/L) specified by Zeng and completely atypical for lithium-ion battery electrolytes

147. Accordingly, in my opinion, Zeng suggests or renders obvious a Z range falling entirely within the claimed Z range.

H. Claim 12

1. [12.1] “The electrochemical device according to claim 1, wherein the electrolyte further comprising one selected from a group consisting of: a cyclic carbonate ester having a carbon-carbon double bond, a fluorinated chain carbonate ester, a fluorinated cyclic carbonate ester, a compound having a sulfur-oxygen double bond, and any combination thereof.”

148. In my opinion, Zeng discloses or suggests this element. In Zeng Embodiments 4 and 6, *the electrolyte further comprises a compound having a sulfur-oxygen double bond*—1,3-propanesultone (PS)—as claimed. EX1006, ¶¶ [0037], [0049].

I. Claims 14, 15 and 17

149. In my opinion, the Zeng-Sunose combination renders obvious claims 14, 15, and 17 for reasons I discussed above for elements of claims 1, 2, and 5, as indicated in the table below. As noted above, I understand Patent Owner has equated claim 14 and claim 1 in litigation, contending that claim 14 reads on an electrode with single-sided and double-sided portions for the same reasons claim 1 does. Specifically, I understand Patent Owner asserted that the same accused electrode infringed both claims 1 and 14 and Patent Owner's entire explanation for elements of claim 14 were citations back to elements for claim 1. Applying Patent Owner's position here, the elements of claim 14 are taught by the prior art for the same reasons as the elements of claim 1 addressed above:

Claim 14		
Element	Text	Reasoning
[14.pre]	<i>An electrochemical device, comprising:</i>	See Section IX.B.1 above regarding element [1.pre].
[14.1]	<i>electrodes; and</i>	See Section IX.B.2 above regarding element [1.1]. As explained, Zeng's lithium-ion batteries have two <i>electrodes</i> —a cathode and an anode.
[14.2]	<i>an electrolyte comprising a dinitrile compound, a trinitrile compound, and propyl propionate;</i>	See Section IX.B.3 above regarding element [1.2].

[14.3]	<i>wherein, based on the 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 wt %$\leq(X+Y)\leq$about 8 wt%, and about 0.1$\leq(X/Y)\leq$about 6;</i>	See Section IX.B.4 above regarding element [1.3].
[14.4]	<i>wherein, the electrodes comprise a first electrode and a second electrode,</i>	See Sections IX.B.2, IX.B.5 above regarding elements [1.1], [1.4].
[14.5]	<i>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</i>	See Sections IX.B.2, IX.B.5, IX.B.6 above regarding elements [1.1], [1.4], and [1.5]
[14.6]	<i>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;</i>	See Section IX.B.6.b above regarding element [1.6].
[14.7]	<i>wherein based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z; wherein, about 0.01$\leq(Y/Z)\leq$about 0.3;</i>	See Section IX.B.7 above regarding element [1.7].

[14.8]	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.	See Section IX.B.8 above regarding element [1.8].
Claim 15		
Element	Text	Reasoning
[15.1]	The electrochemical device according to claim 14, wherein the first electrode is a cathode, the second electrode is a cathode, and $3.5 \text{ g/cm}^3 \leq D_2 \leq 4.3 \text{ g/cm}^3$.	See Section IX.C above regarding element [2.1]. As explained above, Sunose's electrode configuration, incorporated into Zeng's lithium-ion battery, pertains to the <i>cathode</i> (positive electrode). Thus, in the Zeng-Sunose combination, the single- (left side) and double-sided (right side) coating portions of Sunose's current collector 3 in Figure 1 respectively correspond to the claimed <i>first electrode</i> and <i>second electrode</i>—both of which are “a cathode”, as claimed.

Claim 17		
Element	Text	Reasoning
[17.1]	<i>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-dicyanoheptane, 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-dioxapimelonitrile, 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-</i>	See Section VIII.E above regarding element [5.1].

<i>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.</i>	
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150. Accordingly, in my opinion, Zeng and Sunose render obvious claims 14, 15 and 17.

X. GROUND 2A: ZENG AND SUNOSE, FURTHER IN VIEW OF SU, RENDER OBVIOUS CLAIMS 3 AND 16

151. Claims 3 and 16 of the '131 Patent relate to anodes with compaction density $D2$. In my opinion, while Zeng and Sunose focus on electrolytes and cathodes, respectively, a POSITA would have also understood that any lithium-ion battery also needs an anode. This need, together with the need for a high-performing anode configuration, would have led a POSITA to Su, which discloses *anodes* having the double-sided compaction density $D2$ of claims 3 and 16. In my opinion, a POSITA would, therefore, have found it obvious to use Su's anode in the Zeng/Sunose battery to arrive at claims 3 and 16.

A. Claims 3 and 16

1. Elements [3.1], [3.2], [16.1]

- a. [3.1] “The electrochemical device according to claim 1, wherein the electrode is an anode, and”**

152. In my opinion, Zeng discloses or suggests this claim element. *Supra* Section IX.B.2; IX.C, IX.I.

- b. [3.2] “ $1.2 \text{ g/cm}^3 \leq D2 \leq 1.8 \text{ g/cm}^3$ ”**

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

153. In my opinion, by definition, a lithium-ion battery requires a cathode and an anode (among other things). And while Zeng and Sunose do not disclose focus on anodes, in my opinion, Su does. Specifically, Su’s Examples 2 and 3 batteries had the following single- and double-sided coating compaction densities $D1$, $D2$ for the negative electrode (anode).

Example	$D2$
2	1.8 g/cm^3
3	1.5 g/cm^3

See EX1012, ¶¶ [0059]-[0064].

154. As highlighted in the Table above, Examples 2 and 3 of Su have $D2$ values falling in the claimed range.

155. Thus, Su discloses Elements [3.2] and [16.1].

c. Rationale to Combine

- **Teaching, suggestion, motivation**

156. Su is analogous art to Zeng and Sunose because it also seeks to improve performance of lithium-ion batteries—using electrode configuration to increase energy density. *See* EX1012, Title, Abstract, ¶¶ [0005]-[0024]. In my opinion, a POSITA would have found it obvious, with a reasonable expectation of success, to implement Su’s Examples 2 and 3 configurations for the negative electrode (anode) of Zeng/Sunose.

157. **Anode implementation details:** Sunose describes a rolled electrode configuration and focuses primarily on the positive electrode (cathode), leaving out anode implementation details. But, in my opinion, a POSITA would need anode implementation details, too, to implement the Zeng/Sunose battery. In my opinion, Su, which, like Sunose, describes a rolled electrode configuration, would have commended itself to a POSITA looking for anode implementation details, including appropriate compaction densities for the single- and double-sided coating portions of the current collector. EX1012, ¶¶ [0039]-[0040].

158. **Energy density:** Zeng and Sunose both emphasize a market demand for high energy density, so in my opinion a POSITA considering these references would have been on the lookout for ways to boost energy density. *See, e.g.*, EX1006, ¶ [0003]; EX1010, ¶ [0002]. Su’s electrode configuration—including the anode

configuration—is designed to improve energy density, and indeed, all Su’s Example batteries had strong performance in capacity and energy density over more than 2000 cycles. EX1012, ¶¶ [0041], [0058], [0061], [0064], [0067], [0070], [0073], [0076]. Thus, in my opinion, the need for anode implementation details in the Zeng-Sunose battery, together with the market need to improve energy density recognized in Zeng, Sunose, and Su, would have further enticed the POSITA to use Su’s anode in Zeng/Sunose.

- **Obvious to try**

159. Moreover, in my opinion, a POSITA would have found it obvious to try Su’s Example 2 and 3 anode configurations in Zeng/Sunose.

160. **Recognized need in the art:** Like Zeng and Sunose, Su observes an underlying market need for high energy density lithium batteries for applications including mobile devices, electric vehicles, and electric tools. EX1012, ¶¶ [0001]-[0003]. Because of this market need “the performance of lithium ion batteries is facing higher development requirements, and high energy density has become one of the research directions of high-performance lithium-ion batteries.” *Id.*, ¶ [0003].

161. **Finite number of identified, predictable solutions:** Su only discloses seven Example batteries and one comparative Example, so in my opinion, a POSITA would have found it obvious to try all Examples. EX1012, ¶¶ [0050]-[0084]. Examples 2 and 3 had well-balanced capacity and energy density compared to the

other Examples, including above-average performance. In my opinion, this blend of balanced characteristics would have directed the POSITA to Examples 2 and 3.

- **Reasonable expectation of success**

162. In my opinion, because Sunose and Su both describe wound/rolled electrode configurations, it is my opinion that a POSITA would have had a reasonable expectation of success in combining the two. EX1010, ¶¶ [0006]-[0008]; EX1012, Claims 3-5, ¶¶ [0014]-[0016], [0028], [0036]-[0040]. Both electrode current collectors of Su have single- and double-sided coating portions. EX1012, ¶¶ [0038]-[0040]. While Sunose focuses on cathode details, Sunose's cathode and Su's anode share similar single-sided and double-sided configurations. All Su's Example batteries were successfully tested over more than 2000 cycles, exhibiting good results in capacity and energy density. EX1012, ¶¶ [0041], [0058], [0061], [0064], [0067], [0070], [0073], [0076]. Su provides instructions to prepare its lithium battery, including how to make the single- and double-sided coating parts of the anode. *See id.*, Claims 2-10, ¶¶ [0008]-[0021], [0030]-[0040]. In my opinion, this would have given a POSITA a reasonable expectation of success in implementing Su's Examples as the anode in the Zeng/Sunose battery.

163. Accordingly, in my opinion, Zeng and Sunose, further in view of Su, render obvious claims 3 and 16.

XI. GROUNDS 1B, 2B: ZENG AND SUNOSE, FURTHER IN VIEW OF MATSUOKA, RENDER OBVIOUS CLAIMS 1, 2, 4-7, 12, 14, 15, AND 17; ZENG, SUNOSE, AND SU, FURTHER IN VIEW OF MATSUOKA, RENDER OBVIOUS CLAIMS 3 AND 16

164. I have been asked to consider that Patent Owner may argue Zeng is ambiguous about adding LiPF_6 , and thus the weight proportion of the solvent components in the electrolyte is unclear. In my opinion, this argument, if raised, lacks merit, for the reasons I explained in Ground 1A.

165. But for the sake of completeness, it is my opinion that any potential ambiguity can be dispelled by Matsuoka, which explicitly discloses an appropriate amount of PP (Z). Alternate Grounds 1B and 2B, I rely on Matsuoka for elements [1.7] and [14.7] of the independent claims. Under this analysis, it is my opinion that the Challenged Claims elements remain obvious. For the remaining claim elements, I incorporate by reference my analysis above for those claim elements in Grounds 1A and 2A. Supra Sections IX-X.

A. Overview of Matsuoka—Electrolyte Specifying Non-nitrile Additives (e.g., PP) by Weight

166. Matsuoka describes a “non-aqueous electrolyte solution” that includes the nitrile additive “acetonitrile and a lithium salt,” as well as a “non-nitrile additive,” to improve the durability of the SEI layer formed on the electrode surface. EX1007, Abstract, ¶¶ [0015], [0035], [0044], [0056], [0057]. According to Matsuoka, a durable SEI layer better protects the electrodes, reducing side reactions

and maintaining lower internal resistance which improves high-temperature storage and cycling performance. *Id.*, ¶¶ [0022], [0036], [0057].

167. Like Kim, Matsuoka identifies PP as a beneficial non-nitrile electrolyte component. Specifically, Matsuoka lists PP isomers having LUMO (Lowest Unoccupied Molecular Orbital) and HOMO (Highest Occupied Molecular Orbital) energies falling in or near most-preferred ranges, which improves SEI film durability. *Id.*, ¶¶ [0038], [0040]; *see also id.*, ¶¶ [0015], [0036], [0039]. Matsuoka teaches that an ideal LUMO level improves reducibility of the non-nitrile additive, helping to form the SEI film on the negative electrode while “provid[ing] good effects on ... a positive electrode and a separator” and suppressing “an increase in internal resistance caused by repeating charge-discharge cycles[.]” *Id.*, ¶ [0036]. An ideal HOMO level distributes the protective effects of the SEI layer to other components of the battery, including the positive electrode. *Id.*, ¶ [0039]. And together, optimum LUMO and HOMO levels suppress side reactions, improving overall performance. *Id.*, ¶ [0022]. Matsuoka explains:

By adjusting the LUMO energy of the specific additive in the above described range, it is not only effective for the formation of a protective film on a negative electrode, but it also suppresses nonelectrochemical side reactions caused by extremely high reducibility. Furthermore, differing from the case of an extremely low LUMO energy, the product generated as a result of the reductive reaction is not strongly fixed only

on a negative electrode, but in some form, it provides good effects on members other than the negative electrode, such as a positive electrode and a separator. *As a result, an increase in internal resistance caused by repeating charge-discharge cycles can be suppressed.*

EX1007, ¶ [0036].

B. Elements [1.7] and [14.7]

1. Matsuoka discloses “a weight percentage of the propyl propionate is Z”

168. Matsuoka teaches two preferred weight proportion ranges for the non-nitrile additive (e.g., PP) in the total electrolyte:

Matsuoka Range	Non-nitrile Additive (wt%)	Citation
Preferably	0.1 to 30	EX1007, ¶ [0041]
More preferably	0.1 to 10	

169. Thus, in my opinion, to the extent that a POSITA sought to use an advantageous amount of PP in Zeng’s electrolyte, Matsuoka provides, and explains the benefits of, such an amount. In my opinion, Matsuoka therefore discloses *a weight percentage of the PP is Z*. And, as I explain below, when used in Zeng’s electrolytes, Matsuoka’s amount of PP results a Y/Z ratio overlapping that range recited in elements [1.7] and [14.7].

2. Rationale to combine

170. In my opinion, a POSITA would have been motivated, with a reasonable expectation of success, to incorporate Matsuoka's preferred non-nitrile *weight percentages* as the *weight percentage of the PP is Z* in Zeng's Embodiments 4 and 6.

- **Analogous art**

171. In my opinion, Matsuoka is analogous art to the '131 Patent, Zeng, Sunose, and Su because it also relates to the field of endeavor of lithium-ion batteries, including for mobile devices. EX1007, ¶¶ [0001]-[0005], [0212]. And Zeng and Matsuoka strive to improve long-term battery performance, just like the '131 Patent. The '131 Patent observes that, "at high voltages, the oxidation activity ... increases, ... 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." EX1001, 1:32-37. The '131 Patent thus seeks compositions that "inhibit[] the side reactions in the electrochemical device ... to improve the long-term storage performance and reliability of the electrochemical device," EX1001, 2:48-52, highlighting reducing side reactions as "important to controlling the expansion of electrochemical devices." *Id.*, 3:15-20.

172. Zeng uses the solvent "[f]luoroethylene carbonate (FEC), which has good film-forming properties and resistance to oxidation" and "ensures good high-

voltage cycling performance of the battery without seriously affecting the high-temperature performance of the battery.” EX1006, ¶ [0028]. Likewise, Matsuoka uses its non-nitrile additive such as PP to form a stable protective film on the negative electrode, suppressing side reactions that generate gas and rise in internal resistance that can damage the battery and/or hurt cycling performance. EX1007, ¶¶ [0011], [0022], [0036], [0042], [0057], [0104]. Thus, in my opinion, a POSITA would have considered Matsuoka.

173. Like Zeng and Matsuoka, the ’131 Patent focuses on long-term battery performance, explaining that, “at high voltages, the oxidation activity ... increases, ... 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.” EX1001, 1:32-37. The ’131 Patent seeks compositions that “inhibit[] the side reactions ... to improve the long-term storage performance and reliability of the electrochemical device,” *id.*, 2:48-52, highlighting reducing side reactions as “important to controlling the expansion of electrochemical devices.” *Id.*, 3:15-20. Thus, in my opinion, a POSITA would have combined the teachings of Zeng and Matsuoka for the same reasons to achieve the same purported benefits.

- **Teaching, suggestion, motivation**

174. **Implementation details:** In my opinion, to 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. In my opinion, a POSITA would have noted Matsuoka's "off-the-shelf" preferred weight proportion ranges for PP, a non-nitrile additive, to fine-tune the weight percentage Z of PP in Zeng Embodiments 4 and 6.

175. **Balanced performance:** Additionally, Matsuoka explains that its preferred weight proportion ranges for non-nitrile additives like PP balance competing advantages of electrolyte stability and high-rate performance at low temperatures. EX1007, ¶ [0041]. Specifically, Matsuoka explains that increasing the amount by weight of the non-nitrile additive improves electrolyte stability, which comes at the cost of low-temperature performance, and vice versa. *Id.* By calibrating the non-nitrile additive in Matsuoka's preferred weight proportion ranges, however, "all of the cycling performance of the electrolyte solution, high-rate performance under a low temperature environment, and other battery characteristics can be further improved." *Id.* So, the desire for balanced performance, as taught by Matsuoka, would have, in my opinion, motivated the POSITA to use Matsuoka's preferred weight proportion ranges as the amount of PP in Zeng's Embodiment 4 and 6 electrolytes.

- **Reasonable expectation of success**

176. In my opinion, a POSITA would have had a reasonable expectation of success in using Matsuoka's preferred non-nitrile weight proportions for PP in

Zeng's Embodiment 4 and 6 electrolytes. First, in my opinion, Zeng's and Matsuoka's electrolytes compositions are substantially similar, which would have reasonably ensured success. *Id.* Indeed, Zeng's and Matsuoka's electrolytes share the same carbonate-based solvents (EC, PC), the same ester compound (EP), the same lithium salt (LiPF₆), and the same additive (VC). *Compare* EX1006, ¶¶ [0011]-[0019], [0037] *with* EX1007, ¶¶ [0029], [0030], [0034]. And Zeng and Matsuoka both use electrolyte components to improve the SEI film. *Compare* EX1006, ¶¶ [0005], [0028], [0034] *with* EX1007, ¶¶ [0022], [0026], [0030].

177. Thus, in my opinion, a POSITA would have reasonably expected the preferred weight proportions of Matsuoka's non-nitrile additive (here, PP) to be especially suitable as the weight percentage Z of PP to use in Zeng's Embodiment 4 and 6 electrolytes—particularly because Matsuoka describes non-nitrile additives as generally combinable, interchangeable, and “not particularly limited.” EX1007, ¶ [0035]. In particular, in my opinion, a POSITA would generally expect the combination of Zeng's and Matsuoka's electrolytes to have significant benefits described in both references: (1) “a wide-temperature-range ... [with] good lithium ion transport properties, electrode plate wettability, and interfacial compatibility,” EX1006, ¶ [0009], and (2) “high-rate performance under a low temperature environment.” EX1007, ¶ [0041].

3. The Zeng/Sunose/Matsuoka combination teaches or suggests with the claims

178. The proposed combination teaches or suggests the claimed Y/Z ranges:

Y (Zeng)	Z (Matsuoka)	Y/Z
1 wt%	0.1-10 wt%	0.1 to 10
	0.1-30 wt%	0.033 to 10

179. As shown above, selecting Matsuoka's more preferred range for PP (0.1-10 wt%) in Embodiments 4 and 6 of Zeng results in a Y/Z range from 0.1 to 10, overlapping the claimed range 0.01 to 0.3 of Elements [1.7] and [14.7]. Similarly, selecting Matsuoka's preferred range (0.1-30 wt%) results in Y/Z a range from 0.033 to 10, again overlapping the claimed range. *Id.*

180. Matsuoka also highlights PP's ability to keep the battery's internal resistance low. The '131 Patent acknowledges that known film-forming additives increase a battery's internal resistance due to the SEI layer they form, indicating a need for improvement. EX1001, 1:30-62. In my opinion, a POSITA, seeking enhancements based on Zeng, would recognize from Matsuoka that PP effectively suppresses rise in internal resistance. A POSITA would therefore have adjusted the PP content in Zeng's Embodiments 4 and 6 within Matsuoka's preferred ranges of 0.1-10 wt% and 0.1-30 wt%, seeking to optimize the PP proportion for suppressing rise in internal resistance. EX1007, ¶ [0036].

181. Accordingly, in my opinion: (1) Zeng and Sunose, further in view of Matsuoka, renders obvious claims 1, 2, 4-7, 12, 14, 15, and 17; and (2) Zeng, Sunose, and Su, further in view of Matsuoka, renders obvious claims 3 and 16.

XII. GROUNDS 1C, 2C: ZENG/SUNOSE/MATSUOKA—FURTHER IN VIEW OF KIM—RENDER OBVIOUS CLAIMS 1, 2, 4-7, 12, 14, 15, AND 17; ZENG/SUNOSE/ MATSUOKA/SU—FURTHER IN VIEW OF KIM—RENDER OBVIOUS CLAIMS 3 AND 16

182. I have been asked to consider a potential argument by Patent Owner that Elements [1.7] and [14.7] require specific focus on Y/Z (the ratio of trinitrile to PP) and criticize Zeng and Matsuoka for not highlighting the ratio of HTC_N to PP, specifically. Patent Owner would be incorrect for several reasons.

183. First, as established, Zeng discloses Y and Z values that, when expressed as a ratio (Y/Z), fall within the range claimed in the '131 Patent. The mere recitation of this mathematical relationship—expressing known values as a ratio—does not create a patentable distinction over prior art that discloses or renders obvious the underlying Y and Z values.

184. Second, Embodiments 4 and 6 of Zeng disclose dinitrile-based electrolytes further containing a trinitrile and PP, and in different relative amounts. EX1006, ¶¶ [0045]-[0049]. The remaining Embodiments lacked the combination of both a trinitrile and PP. *Id.* In my opinion, given that Zeng Embodiments 4 and 6 were advantageous, this would have drawn the POSITA's attention to the

importance of Zeng's *Y* and *Z* proportions in improving performance of dinitrile-based electrolytes, as well as their relative amounts falling within and overlapping the claimed *Y/Z* ranges.

185. Third, it was known that the relative proportions of *Y* and *Z* were beneficial, thanks to the teachings of Kim. In my opinion, Kim further focuses the POSITA on the notion of including both a trinitrile and PP in a dinitrile-based electrolyte solution and provides more motivation to adjust the relative amounts of these two components (i.e., *Y/Z*) to improve performance. Thus, in my opinion: (1) Zeng/Sunose or Zeng/Sunose/Matsuoka, further in view of Kim, renders obvious claims 1, 2, 4-7, 12, 14, 15, and 17 (Ground 1C); and (2) Zeng/Sunose/Su or Zeng/Sunose/Su/Matsuoka, further in view of Kim, render obvious claims 3 and 16 (Ground 2C).¹⁰

186. Specifically, Kim discloses lithium-ion battery electrolytes that demonstrate superior capacity retention at high temperatures after battery charging cycles. EX1008, ¶ [0005]. Kim even claimed trinitrile- and PP-based electrolytes: Kim's claim 1 recites using a trinitrile (Formula 1) with a C3-to-C5 alkyl propionate

¹⁰ For all remaining claim elements, I incorporate by reference my analysis above for those claim elements in Grounds 1A, 2A, 1B, and 2B. *See supra* Sections IX-XI.

(e.g., PP, a C3 alkyl propionate). *See* EX1008, ¶ [0055] (Formula 1 compounds feature three or more nitrile (CN) groups and an asymmetric structure), Claim 1. According to Kim, “reactivity between an active material and an electrolyte solution is increased, thus a capacity retention is deteriorated during a cycle[.]” *Id.*, ¶ [0005]. As set forth in Kim’s specification, Kim experimented with dinitrile-, trinitrile-, and PP-based electrolytes, noting that after storage at 60°C for four weeks, and after 250 cycles, batteries using electrolytes that have both a trinitrile and PP exhibited improved capacity retention over batteries using electrolytes that lacked either or both components. EX1008, Tables 2-4.

187. Thus, in my opinion, Kim’s Examples underscore the enhanced performance of trinitrile- and PP-based electrolytes against those lacking one or both compounds. This is effectively demonstrated through Examples 1 and 2, as well as Comparative Examples 1-6. Among Examples 1 and 2 and Comparative Examples 1-6 as tested in Kim, only Examples 1 and 2 contained both a HTCEN (trinitrile) and PP—and in different relative amounts. EX1008, ¶¶ [0090]-[0091]. The remaining Comparative Examples 1-6 lacked either HTCEN (trinitrile), PP (or both), as highlighted below. *Id.*, ¶ [0091].

TABLE 1

	Lithium salt (LiPF ₆)	Solvent (volume %)						Additive (wt %)		
		EC	PC	DEC	MP	EP	PP	SN	HTCN	
Example 1	1.15M	20	10	—	—	30	40	1	2	} both trinitrile (HTCN) and PP, in different relative amounts
Example 2	1.15M	20	20	—	—	—	60	1	2	
Comparative	1.15M	20	20	60	—	—	—	3	—	
Example 1										} missing either trinitrile or PP
Comparative	1.15M	20	20	60	—	—	—	1	2	
Example 2										
Comparative	1.15M	20	10	—	—	30	40	3	—	
Example 3										
Comparative	1.15M	20	20	—	—	—	60	3	—	
Example 4										
Comparative	1.15M	20	20	—	60	—	—	1	2	
Example 5										
Comparative	1.15M	20	20	—	—	60	—	1	2	
Example 6										

Kim, Table 1*

188. In my opinion, by disclosing one set of dinitrile-based electrolytes (Examples 1 and 2) containing both a trinitrile and PP in different relative amounts and another set of electrolytes (Comparative Examples 1-6) lacking either the trinitrile or PP, Kim draws the POSITA's attention to Y/Z.

189. Moreover, Kim tested batteries using the example electrolytes, and Examples 1 and 2 (containing both trinitrile and PP) outperformed all Comparative Examples 1-6 (without both compounds) in resisting increase in battery thickness and capacity retention. See EX1008, ¶¶ [0097]-[0103] (Tables 3, 4), FIGS. 3-6. In

my opinion, the POSITA would have noted differences in electrolyte composition: Examples 1 and 2 are the only examples that include both trinitrile and PP, and they outperformed the Comparative Example. In my opinion, this would further focus the POSITA on the importance of trinitrile- and PP-based electrolytes.

190. In my opinion, Kim's Examples would also have directed the POSITA to the importance of PP in particular. That is, Example 2 differs from Comparative Examples 5 and 6 in the substitution of PP (Example 2) with MP or EP (Comparative Examples 5 and 6, respectively) at the same weight percentages. EX1008, ¶ [0090], Table 1. In my opinion, the superior performance of Example 2 confirms PP outshines similar alkyl propionates like MP or EP.

191. In my opinion, Kim also teaches a POSITA that fine-tuning the trinitrile (Y)/PP (Z) ratio optimizes battery performance. Examples 1 and 2 have the same dinitrile and trinitrile contents, but PP increases from 40 wt% (Example 1) 60% (Example 2). EX1008, ¶ [0090], Table 1. Thus, Kim shows that adjusting PP in the trinitrile-based electrolytes of Examples 1 and 2 significantly impacts battery performance. *Id.*, ¶¶ [0092]-[0103].

192. In my opinion, Kim highlights the same technique to improve electrolyte performance as the '131 Patent (adjusting Y/Z) and describes the same basis for the improved performance. Kim teaches that a dinitrile (e.g., succinonitrile (SN)) "may help formation of a film on a negative electrode as well as a positive

electrode” that “suppress[es] gas generation ... when stored at a high temperature” or operated at high voltage (above 4.4V). EX1008, ¶ [0064]; *see also id.*, ¶ [0104]. But gas increases thickness and internal resistance of the battery, hurting storage and cycle performance. *Id.*, ¶¶ [0039], [0063]-[0066]. To address this problem, Kim teaches adding a trinitrile and an alkyl propionate. Specifically, a trinitrile, like HTC_N, gives the protective layer a “stable and strong bonding” force that reduces battery swelling typically caused by high temperature storage and cycling. *Id.*, ¶¶ [0055]-[0056]. Moreover, adding PP further improves high temperature storage and cycling performance. *Id.*, ¶¶ [0014], [0040], [0090], [0091], claim 3.

193. Echoing Kim, the ’131 Patent observes that “[a] dinitrile compound can form a protective film on the cathode of the electrochemical device ... to inhibit the decomposition of the solvent[,]” EX1001, 1:49-51, but that the high working voltages (above 4.4V) required by conventional electronic devices tend to decompose the protective film. *Id.*, 1:30-39, 1:52-55. The ’131 Patent states that the addition of trinitrile forms a durable, protective SEI film on the cathode surface, which resists decomposition. *Id.*, 1:55-62. However, film-forming additives such as dinitrile and trinitrile have an inherent limitation: the protective SEI film they create increases the battery’s DC internal resistance and thickness expansion rate, ultimately compromising storage and cycling performance. *Id.*, 22:31-34. The ’131 Patent does not explain why the protective SEI film leads to an increase in DC

internal resistance. Instead, it highlights that the SEI film formed by a dinitrile and/or trinitrile requires further optimization to address the issue of DC internal resistance.

194. Kim observes that an additive, such as dinitrile succinonitrile (SN), “may help formation of a film on a negative electrode as well as a positive electrode” that “suppress[es] gas generation ... when stored at a high temperature” or operated at high voltage (above 4.4V). EX1008, ¶ [0064]; *see also id.*, ¶ [0104]. Gas generation increases thickness and internal resistance of the battery, hurting storage and cycle performance. *Id.*, ¶¶ [0039], [0063]-[0066]. Like the ’131 Patent, Kim also observes that adding to the electrolyte a trinitrile, like HTC�, “represented by Chemical Formula 1,” gives the protective layer a “stable and strong bonding” force that reduces battery swelling typically caused by high temperature storage and cycling. *Id.*, ¶¶ [0055]-[0056]. And, as discussed, Kim’s Examples and claims demonstrate that further adding PP further improves high temperature storage and cycling performance. *Id.*, ¶¶ [0014], [0040], [0090], [0091], claim 3.

195. Thus, in my opinion, the ’131 Patent and Kim differ in their focus on the effect of PP. The ’131 Patent explicitly states that adding PP to dinitrile- and trinitrile helps suppress DC internal resistance, thereby enhancing battery performance. In contrast, Kim generally shows that the combination of PP with dinitrile and trinitrile improves cycling performance but does not specifically address the suppression of DC internal resistance. *Id.*, ¶¶ [0090]-[0104]. But testing

DC internal resistance was a routine procedure for evaluating electrolyte performance. Since Kim already teaches that adding PP to electrolytes containing dinitrile and trinitrile improves battery performance, in my opinion, a POSITA would have been motivated to follow Kim's teachings. To the extent that testing DC internal resistance matters it would have been routine to evaluate performance of Kim's electrolytes based on internal resistance.

196. Accordingly, in my opinion, Kim would further motivate a POSITA to consider and adjust the proportions of trinitrile and PP in Zeng's electrolytes and/or use Matsuoka's PP amounts in Zeng's electrolytes.

XIII. GROUND 3A: ZHOU AND SUNOSE RENDER OBVIOUS CLAIMS 1, 2, 4-7, 12, 14, 15, AND 17

A. Overview of Zhou—Electrolyte Containing X, Y, and Z in the Claimed Amounts

197. Zhou's Example 8 discloses an adiponitrile-based (ADN) dinitrile electrolyte further containing 1,3,6-hexane trinitrile (HTCN) and the linear carboxylic acid ester ethyl acetate (EA). Example 8 does not contain PP. However, Zhou lists only eight alternative suitable linear carboxyl acid esters—two being EA and PP. PP is structurally-similar to EA but has two additional methyl groups. While PP and EA both have relatively low boiling points suitable for Zhou's purposes, PP's higher boiling point would improve electrolyte and battery safety. In my opinion, it would have been obvious for a POSITA to try the replacement of EA with PP.

Example 8 has 20 wt% EA in the solvent mixture, which gets reduced to 16.56 wt% after adding LiPF_6 and the additives. Replacing EA with PP would thus result in the total electrolyte having between 5 wt% and 20 wt% PP. I rely on Example 8 of Zhou as rendering obvious the Challenged Claims.

198. Zhou describes embodiments of “a fast charging lithium-ion battery electrolyte [having] a high potential and a high compaction density, and ... good cycle performance and high and low temperature performance.” EX1014, ¶ [0006]. Zhou’s electrolytes have the following main components:

- a solvent which “accounts for 70%-88% of the total mass of the lithium-ion battery electrolyte” and “includes a mixture of two or more of a low-boiling-point linear carbonate and a linear carboxylic acid ester, fluorobenzene and hydrofluoroether”;
- a lithium salt;
- an additive package including “[a] third additive [that] is a nitrile compound containing 2 or 3 nitrile functional groups” and that “accounts for 0.5%-5% of the total mass of the lithium-ion battery electrolyte[.]”

Id., ¶¶ [0008], [0009], [0016], [0018].

199. The solvent “adjust[s] the wetting effect and mass transfer resistance of the electrolyte system [so that] a good channel is provided for the lithium-ion

deintercalation process[.]” *Id.*, ¶ [0020]. But “the low-boiling-point linear carbonate and carboxylate introduced into the above-mentioned solvent” has the side effects of “incompatibility with graphite, poor battery cycle performance, and high temperature resistance[.]” *Id.*

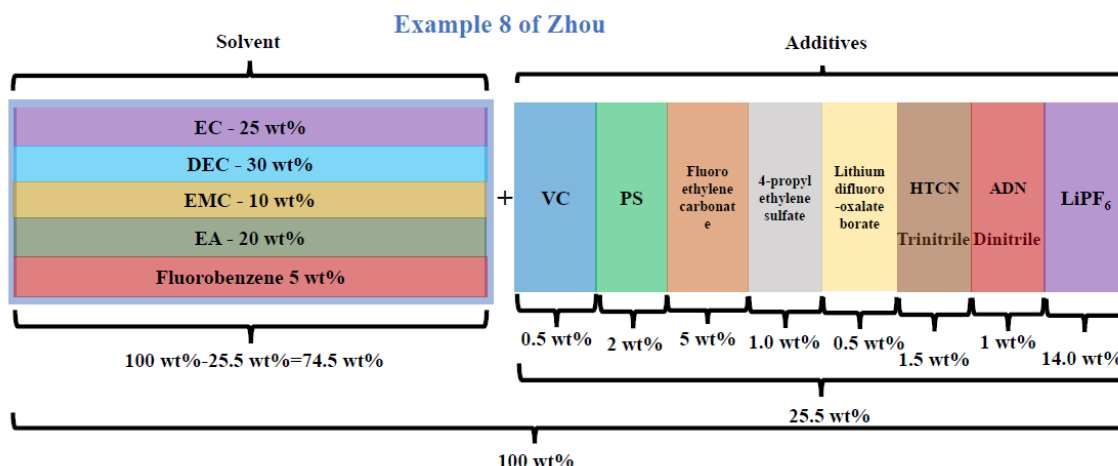
200. The additives, including the nitrile compound(s), “solve the problem of incompatibility with graphite” and “eliminate the deterioration of high-temperature performance caused by the above-mentioned low-boiling-point organic solvent.” EX1014, ¶ [0020]. Zhou prefers “nitrile compounds containing 2 or 3 nitrile functional groups ... to improve the high temperature performance of the battery[.]” *Id.*, ¶ [0059]. “1,3,6-hexane trinitrile is particularly preferred” because it is “[an] efficient high temperature additive” with “better compatibility with the negative electrode and is easier to protect the positive electrode.” *Id.*

201. In the solvent, Zhou prefers “non-methyl carboxylates ... in large quantities” because they are “more conducive to the fast charging of the system under high voltage and high compaction conditions.” *Id.*, ¶ [0058]. Zhou identifies a handful of suitable linear carboxylic acid esters: “[PP], ethyl propionate, propyl acetate, butyl propionate, ethyl acetate, isopropyl propionate, ethyl butyrate, and methyl acetate.” *Id.*, ¶ [0011].

202. When Zhou describes electrolyte composition, Zhou refers to all additives based on “the total mass of the lithium-ion battery electrolyte.” EX1014,

¶¶ [0009], [0013]-[0016], [0018]. Example 8 of Zhou contains EA (PP substitute) as a solvent, the *dinitrile* adiponitrile (ADN), and the *trinitrile* 1,3,6-hexane trinitrile (HTCN). *Id.*, ¶ [0047]. Specifically, “ethylene carbonate, dimethyl carbonate, ethyl methyl carbonate, ethyl acetate, and fluorobenzene are mixed uniformly in a *mass ratio* of 25:30:10:20:5.” *Id.* Then, “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.” *Id.*

203. Example 8 of Zhou has the following composition, with the combined mixture totaling 100 wt%:



204. **Weight percentage of ADN (dinitrile) in the total electrolyte:** ADN is a dinitrile, as claimed, because it has two nitrile (-CN) groups in its structure, with the molecular structure $\text{NC-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CN}$. EX1018, 1. As illustrated above, in the total Example 8 electrolyte after mixing the additives with the solvent mixture, ADN has a weight percentage (the claimed X) of 1 wt%.

205. **Weight percentage of HTCN (trinitrile) in the total electrolyte:** HTCN is a *trinitrile*, as claimed, because it has three -CN groups with the molecular formula $\text{C}_9\text{H}_{11}\text{N}_3$. EX1018, 100; EX1020. As illustrated above, in the total electrolyte of Example 8 and after mixing the additives with the lithium salt and solvent, HTCN has a weight ratio (the claimed Y) of 1.5 wt%.

206. **Weight percentage of EA in the total electrolyte:** As illustrated above, in the total electrolyte of Example 8 and after mixing the additives with the lithium salt and solvent, EA has a weight ratio (denoted as Z') of $(1-25.5\%)\times(20\%/(25\%+30\%+10\%+20\%+5\%))=16.56\%$.

207. In summary, the claimed X, Y, and Z' have the following values in Zhou's Example 8:

X (Weight Percentage ADN in Total Electrolyte)	Y (Weight Percentage HTCN in Total Electrolyte)	Z' (Weight Percentage EA in Total Electrolyte)
1 wt%	1.5 wt%	16.56 wt%

208. In Example 8, Zhou found improved discharge capacity of lithium-ion batteries, as shown in Figure 1. In particular, the battery using the Example 8 electrolyte showed improved discharge capacity over not only Comparative Example 3, but also Examples 3-6. EX1014, ¶ [0061], FIG. 1. Zhou also found that Example 8 exhibits lower internal impedance of lithium-ion batteries than Comparative Examples 1-3 and Examples 1, 2, 4, and 6 as shown in Figure 4. *Id.*, ¶¶ [0057]-[0058], FIG. 4.

- **Rationale to Implement Zhou Example 8**

209. Each Example in Zhou is a self-contained, working embodiment that provides a complete list of components, amounts, and preparation instructions. In my opinion, a POSITA would have been motivated to implement the electrolyte of Zhou's Example 8 with a reasonable expectation of success. The Example 8 battery not only significantly outperformed the Comparative Example batteries on discharge capacity and low impedance, but also outperformed four other Examples on discharge capacity, and outperformed four other Examples on low impedance. See EX1014, ¶¶ [0057], [0061], FIGS. 1, 4. This would have motivated the POSITA to implement Example 8 over other Examples.

210. Furthermore, in my opinion, it would have been obvious to try Example 8 of Zhou:

211. **Recognized need in the art:** In my opinion, Zhou observes a market need for “the development of fast charging technology” driven by “the popularization of smart digital products [and] the application of new energy vehicles[.]” EX1014, ¶¶ [0002]-[0003]. Conventionally, “low-boiling-point organic solvents are commonly used to improve the kinetic properties of the electrolyte,” such as “better wettability [and] lower viscosity[.]” *Id.*, ¶¶ [0003]-[0004]. “However, the use of these solvents will cause the high temperature performance of the battery to be challenged” and “poor compatibility of carboxylic acid ester organic solvents with the negative electrode graphite of the battery will cause the battery cycle performance to deteriorate.” *Id.*, ¶ [0004]. Zhou thus sought “a combination of solvents and additives that matches the fast charging electrolyte” and thereby “[i]mprov[es] battery kinetics, high temperature performance, and cycle performance[.]” *Id.*, ¶ [0005]. Given that Zhou Example 8 achieved these goals, a POSITA would have appreciated that it met recognized needs in the art.

212. **Finite number of identified, predictable solutions:** Zhou only discloses eight electrolyte solutions to address this need, Examples 1-8, which had better discharge capacity and lower impedance than the Comparative Examples. *Id.*, ¶¶ [0032]-[0048]. Notably, Example 8 outperformed Examples 3-6 in discharge capacity and outperformed Examples 1, 2, 4, and 6 in internal impedance. EX1014, ¶¶ [0057], [0058], [0061], FIGS. 1, 4.

213. **Reasonable expectation of success:** All Zhou's Examples were successfully tested in batteries and had better performance than the Comparative Examples. EX1014, ¶¶ [0057]-[0063]. According to Zhou, the Examples successfully showed that "[a]n efficient high temperature additive" such as "[n]itrile compounds containing 2 or 3 nitrile functional groups," overcomes the fact that "[t]he high temperature performance is often challenged when using the solvent system of the present invention." *Id.*, ¶ [0059]. Zhou also provides detailed instructions to make the Example electrolyte. *See id.*, ¶ [0047]. In my opinion, this would have given a POSITA a reasonable expectation of success in implementing Example 8.

B. Independent Claim 1

1. [1.pre] "An electrochemical device, comprising"

214. Zhou discloses electrolytes for lithium-ion battery, which is an *electrochemical device*. EX1014, Abstract, ¶¶ [0001]-[0020].

215. Accordingly, in my opinion, Zhou discloses or suggests element [1.pre].

2. [1.1] "an electrode; and"

216. Zhou's lithium-ion battery has positive and negative *electrodes*. *See* EX1014, Abstract, ¶¶ [0002]-[0005]; EX1003, ¶ ____.

217. Accordingly, in my opinion, Zhou discloses or suggests element [1.1].

3. [1.2] “an electrolyte comprising a dinitrile compound, a trinitrile compound, and propyl propionate;”

218. In my opinion, Zhou renders obvious this element. As discussed, I rely on Example 8 of Zhou’s *electrolyte*, implemented in Zhou’s lithium-ion battery, as rendering the Challenged Claims unpatentable. EX1014, ¶ [0047]; *supra* Section XIII.A.

219. As discussed in Section XIII.A, Zhou’s Example 8 electrolyte contains a *dinitrile compound* (ADN) and a *trinitrile compound* (HTCN), as claimed. See EX1014, ¶ [0047]; EX1018, 1, 100. And while Example 8 lacks PP, PP is structurally similar to EA, with a couple extra methyl groups added on each end of the compound. And Zhou specifically identifies PP as one of but a few suitable alternatives to EA, which, in my opinion, renders obvious substituting PP for EA in Example 8, with a reasonable expectation of success.

220. Specifically, Zhou’s Example 8 electrolyte contains a *dinitrile compound* (ADN) and a *trinitrile compound* (HTCN), as claimed. See EX1014, ¶ [0047]; EX1018, 1, 100. Although Example 8 lacks PP, Zhou lists eight linear carboxylic acid esters that are suitable replacements for EA, one being PP. It would have been obvious to replace EA with PP, a compound with a very similar structure. And doing so would have resulted in the claimed subject matter. For example,

Example 8 has 16.56 wt% EA in the total electrolyte, so substituting EA with PP results in PP falling within the claim 7's Z range of 5-50 wt% of the total electrolyte.

d. Zhou discloses PP

221. Zhou's solvent "includes a mixture of two or more of a low-boiling-point linear carbonate and a linear carboxylic acid ester, fluorobenzene and hydrofluoroether." EX1014, ¶ [0008]. Zhou expressly identifies PP and EA as two of nine suitable, alternative linear carboxylic acid esters. *Id.*, ¶ [0011]. Thus, Zhou discloses that its electrolytes can include PP, as claimed.

e. Rationale to substitute PP for EA in Example 8

222. In my opinion, a POSITA would have found it obvious to try substituting PP for EA in Example 8 of Zhou.

223. **Recognized problem/need:** Zhou observes that, in the lithium-ion battery market, "people's demand for fast charging has become more urgent" due to "the popularization of smart digital product[.]" EX1014, ¶ [0002]. Fast charging demands "rapid migration of a large number of lithium-ions" which, in turn, "requires the electrolyte to have higher kinetic properties and smaller mass transfer resistance[.]" *Id.*, ¶ [0003]. Zhou explains that "low-boiling-point organic solvents are commonly used to improve the kinetic properties of the electrolyte[.]" *Id.*, ¶ [0004]. Thus, Zhou discloses that popular demand for fast charging requires organic solvents that improve kinetic properties of lithium-ion battery electrolytes.

224. **Finite number of identified, predictable solutions:** Zhou identifies a solution to the problem of improving kinetic performance of the electrolyte: “a mixture of two or more of a low-boiling-point linear carbonate and a linear carboxylic acid ester[.]” EX1014, ¶ [0008]. As Zhou found, “the melting and boiling points of the linear carbonate and carboxylate solvents ... are both low, providing a more suitable channel for lithium-ion transmission and reducing the impedance of the battery system.” *Id.*, ¶ [0055]; *see also id.*, ¶ [0020] (selecting linear carbonates and linear carboxylates “improves the battery kinetic performance by changing the solvent system” because they “are easy to diffuse, have good wettability, low viscosity and low melting and boiling points as solvents in the solvent system[.]”). Zhou identifies eight potential linear carboxyl acid esters—one of which (EA) is used in Example 8 and another of which is PP. EX1014, ¶ [0011]. Therefore, PP is one of only a handful of solutions to increase kinetic performance suggested by Zhou. Kim had also disclosed that PP improves electrolyte performance, and the two compounds have a similar structure except for PP’s two additional methyl groups relative to EA, so a POSITA would expect replacing EA with PP in Zhou’s electrolyte to work predictably and as Zhou describes.

225. **Reasonable expectation of success:** In my opinion, a POSITA would have had a reasonable expectation of success in replacing one ester (EA) with another (PP) in Zhou’s Example 8 electrolyte. Consistent with Kim’s disclosure that

PP makes an excellent electrolyte enhancer, Zhou lists PP alongside EA in a short list of suitable esters. EX1014, ¶ [0011]. Thus, in my opinion, the POSITA would likewise expect PP to have the properties necessary to succeed in Zhou's electrolytes. *Id.*, ¶ [0057]. Indeed, Zhou teaches that esters, including those listed in Zhou's disclosure, have suitable, low boiling points to promote ion conductivity in the electrolyte. But PP's slightly higher boiling point than that of EA would also improve electrolyte and battery safety, increasing the likelihood of success.

226. Zhou also teaches the benefits of including large quantities, and different types, of carboxylic acid esters in its electrolyte solutions; for example:

As for the selection of the above-mentioned carboxylic acid esters, ... the applicant believes that non-methyl carboxylates at the end can be used in large quantities (accounting for up to 30% of the solvent system), ... which is more conducive to the fast charging of the system under high voltage and high compaction conditions.

Id., ¶ [0058]. Therefore, in my opinion, a POSITA would not expect replacing EA with PP in Example 8 to render the electrolyte inoperable or harm performance. Instead, a POSITA would expect the resulting electrolyte to work as Zhou describes.

- **Simple substitution**

227. In my opinion, replacing EA with PP in Example 8 of Zhou is merely a simple substitution of one known element (the carboxylic acid ester EA) for another

(the carboxylic acid ester PP) which a POSITA could use to obtain predictable results.

228. **Prior art electrolyte:** Zhou's Example 8 electrolyte differs from the claimed electrolyte by substitution of one well-known prior art carboxylic acid ester EA for another carboxylic acid ester PP.

229. **Function of substituted components known in the art:** Zhou lists PP and EA as two of a handful of alternative carboxylic acid esters. EX1014, ¶ [0011]. Zhou explains that carboxylic acid esters have a low melting point and provide a good channel for ion conductivity in lithium-ion battery electrolytes, reducing internal impedance and improving kinetic performance of the electrolyte. *Id.*, ¶¶ [0009], [0057], [0058].

230. **Predictable results:** In my opinion, a POSITA could have substituted PP for EA in Example 8 of Zhou with only routine skill in the art. Zhou instructs mixing the electrolyte components, including 20 wt% EA, in argon glove box and then slowly add and dissolve 14 wt% LiPF₆ to form the total electrolyte. EX1014, ¶ [0047]. In this process, a POSITA could have simply added 20 wt% PP instead of 20 wt% EA. In my opinion, the result of this substitution would have been predictable because Zhou identifies EA and PP as fungible carboxylic acid esters that support lithium-ion conductivity. EX1014, ¶¶ [0009], [0011], [0057], [0058].

4. [1.3] “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 wt % $\leq(X+Y)\leq$ about 8 wt%, and about $0.1\leq(X/Y)\leq$ about 6”

231. In my opinion, Zhou discloses or suggests this element. As I explained above in Section XIII.A, the claimed X and Y have the following values in Zhou’s Example 8:

X	Y	X+Y	X/Y
1 wt%	1.5 wt%	2.5 wt%	0.67

232. Thus, in Example 8, $X + Y = 1 \text{ wt\%} + 1.5 \text{ wt\%} = 2.5 \text{ wt\%}$, falling in the claimed X+Y range of about 2 wt% to about 8 wt% and thus, in my opinion, rendering it obvious. Additionally, in Example 8, X/Y in Example 8 is $1/1.5=0.67$, also in the claimed X/Y range.

5. [1.4] “wherein, the electrode comprises a current collector,”

233. In my opinion, Zhou discloses or suggests this element. Zhou discloses electrolytes, including Example 8, for lithium-ion batteries. See EX1014, Abstract, ¶¶[0002]-[0006], [0020], [0047], [0057], [0061]. A lithium-ion batteries, by definition, have positive and negative electrodes that each comprise a current collector, as claimed. See also EX1010, Abstract, ¶ [0021], [0047].

234. Accordingly, in my opinion Zhou discloses or suggests element [1.4].

6. **[1.5] “a single-sided coating and a double-sided coating; a first part of the current collector is provided with the single-sided coating and a second part of the current collector is provided with the double-sided coating;”**

[1.6] “an electrode compaction density of the electrode corresponding to the first part with the single-sided coating is D1, and, an electrode compaction density of the electrode corresponding to the second part with the double-sided coating is D2, wherein, about $0.8 \leq D1/D2 \leq$ about 1.2;”

235. Zhou does not disclose these elements but, in my opinion, Sunose does.

Supra Section IX.B.6. In my opinion, for the reasons discussed above in Ground 1A, a POSITA would have found it obvious use Sunose’s cathode with Zhou’s electrolyte. *Supra* Section IX.B.6.c. In my opinion, Sunose is analogous art because Sunose also relates to lithium-ion batteries, including those employing non-aqueous electrolytes. See EX1010, Abstract, ¶¶ [0001]-[0011], [Claim 3]; EX1014, ¶¶ [0001]-[0008]; EX1001, 1:19-3:26. Because Zhou focuses on electrolytes rather than physical configuration of battery elements, in my opinion, a POSITA would have looked to Sunose for implementation details for its improved electrode. *Supra* Sections IX.B.6.c, XIII.A. In my opinion, a POSITA would have had a reasonable expectation of success in using Sunose’s rolled electrode configuration in Zhou’s example batteries because Zhou does not describe any physical specifications or restrictions for its battery or electrode configuration. Also, the proposed combination with Sunose already uses a rolled electrode configuration.

7. [1.7] “wherein based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z; wherein, about $0.01 \leq (Y / Z) \leq$ about 0.3;”

236. In my opinion, Zhou discloses or suggests this element. Zhou discloses that the amount of EA (Z') is 16.56 wt% in Example 8 and, in my opinion, renders obvious substituting PP for EA. *Supra* Section XIII.A. The claimed Y and Z have the following values in the obvious modification to Zhou Example 8:

Y	Z (PP substituted for EA)	Y/Z
1.5 wt%	16.56 wt%	0.091

237. Thus, in modified Zhou Example 8, $Y/Z=0.091$, falling in the claimed range of about 0.01 to about 0.3 and, in my opinion, rendering it obvious.

8. [1.8] “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.”

238. In my opinion, Zhou discloses or suggests this claim element. Zhou Example 8 has 1,3,6-hexanetricarbonitrile (HTCN) as the claimed *trinitrile compound*. EX1014, ¶ [0047]; *supra* Section XIII.A.

C. Claim 2

1. [2.1] “The electrochemical device according to claim 1, wherein the electrode is a cathode, and $3.5 \text{ g/cm}^3 \leq D2 \leq 4.3 \text{ g/cm}^3$.”

239. In my opinion, the Zhou-Sunose combination includes this element. Zhou’s lithium-ion battery is an electrochemical device that, by definition, has a *cathode*. See EX1014, Abstract, ¶¶ [0002]-[0005]. Sunose’s packing density D2 for the double-sided portion—4.0 in all four Examples—falls within Element [2.1]’s range of 3.5 g/cm^3 to 4.3 g/cm^3 . *Supra* Section IX.C.

D. Claim 4

1. [4.1] “The electrochemical device according to claim 1, wherein the dinitrile compound further comprises a compound of Formula (4):



where R_1 selected from an alkylene group having 1-5 carbon atoms or an alkenylene group having 2-5 carbon atoms.”

240. In my opinion, Zhou discloses or suggests this claim element. Zhou’s *dinitrile compound* is adiponitrile which, as explained above in Section IX.D, satisfies claimed Formula 4. See EX1014, ¶ [0047]; EX1001, 7:13-19; EX1018, 1. The ’131 Patent identifies adiponitrile specifically as one of the compounds satisfying Formula [4]. EX1001, 7:13-19.

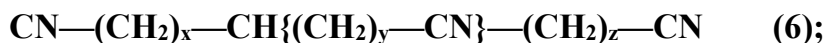
E. Claim 5

1. [5.1] “The electrochemical device according to claim 1, wherein the dinitrile compound is one selected from the group consisting of butanedinitrile, glutaronitrile, adiponitrile, 1,5-dicyanopentane, 1,6-dicyanohexane, 1,7-dicyanoheptane, 1,8-dicyanooctane, 1,9-dicyanononane, 1,10-dicyanodecane, 1,12-dicyanododecane, tetramethylbutanedinitrile, 2-methylglutaronitrile, 2,4-dimethylglutaronitrile, 2,2,4,4-tetramethylglutaronitrile, 1,4-dicyanopentane, 2,6-dicyanoheptane, 2,7-dicyanooctane, 2,8-dicyanononane, 1,6-dicyanodecane, 1,2-dicyanobenzene, 1,3-dicyanobenzene, 1,4-dicyanobenzene, 3,5-dioxapimelonitrile, 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.”

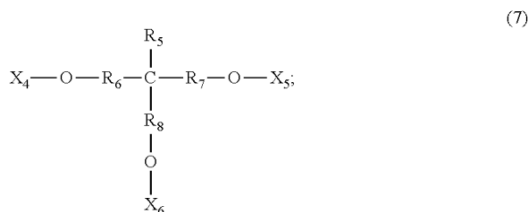
241. In my opinion, Zhou discloses or suggests this element. As I explained above, Example 8 of Zhou has adiponitrile (ADN) as the claimed *dinitrile compound*. EX1014, ¶ [0047]; *supra* Section XIII.A.

F. Claim 6

1. [6.1] “The electrochemical device according to claim 1, wherein the trinitrile compound comprises a compound of Formula (6)



Formula (7)



or a combination thereof,

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

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

242. In my opinion, Zhou discloses or suggests this claim element. As I discussed above, Example 8 of Zeng has 1,3,6-hexanetricarbonitrile (HTCN) as the claimed *trinitrile compound*, which satisfies Formula (6). EX1014, ¶ [0047]; see also EX1018, 100-103; EX1020; EX1001, 7:41-8:27; *supra* Sections XIII.A; IX.F.

G. Claim 7

1. [7.1] “The electrochemical device according to claim 1, wherein X is about 0.01-10 wt %, Y is about 0.01-10 wt%, and a weight percentage Z of the propyl propionate is about 5-50 wt%..”

243. In my opinion, Zhou discloses or suggests this claim element. As I explained above in Section IX.A, in the obvious modification to Zhou Example 1—replacing EA with PP--X, Y, and Z have the following values, falling within the claimed ranges for X, Y, and Z:

X	Y	Z (PP, substituted for EA)
1 wt%	1.5 wt%	16.56 wt%

H. Claim 12

1. [12.1] “The electrochemical device according to claim 1, wherein the electrolyte further comprising one selected from a group consisting of: a cyclic carbonate ester having a carbon-carbon double bond, a fluorinated chain carbonate ester, a fluorinated cyclic carbonate ester, a compound having a sulfur-oxygen double bond, and any combination thereof.”

244. In my opinion, Zhou discloses or suggests this claim element. Specifically, in Example 8, *the electrolyte further comprises a compound having a sulfur-oxygen double bond*—1,3-propane sultone (PS)—as claimed. EX1014, ¶ [0047].

I. Claims 14, 15 and 17

245. In my opinion, Zhou and Sunose render obvious claims 14, 15, and 17 for reasons discussed above for claims 1, 2, and 5 in this Ground and reasons discussed above regarding claims 14, 15, and 17 in Ground 1A. *Supra* Sections IX.I, XIII.B, XIII.C, XIII.E.

Claim 14		
Element	Text	Reasoning
[14.pre]	<i>An electrochemical device, comprising: and</i>	See Section XIII.B.1 above regarding element [1.pre].
[14.1]	<i>electrodes; and</i>	See Section XIII.B.2 above regarding element [1.1].
[14.2]	<i>an electrolyte comprising a dinitrile compound, a trinitrile compound, and propyl propionate;</i>	See Section XIII.B.3 above regarding element [1.2].
[14.3]	<i>wherein, based on the 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 wt % $\leq (X+Y) \leq$ about 8 wt%, and about 0.1 $\leq (X/Y) \leq$ about 6;</i>	See Section XIII.B.4 above regarding element [1.3].
[14.4]	<i>wherein, the electrodes comprise a first electrode and a second electrode,</i>	See Sections XIII.B.2 (Element [1.1]), XIII.B.5 (Element [1.4]), IX.I (Ground 1A, Element [14.4]).
[14.5]	<i>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</i>	See Sections XIII.B.2 (Element [1.1]), XIII.B.5 (Element [1.4]), XIII.B.6 (Element [1.5]), IX.I (Ground 1A, Element [14.4]).

[14.6]	<i>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;</i>	See Section XIII.B.6 above regarding element [1.6].
[14.7]	<i>wherein based on the total weight of the electrolyte, a weight percentage of the propyl propionate is Z; wherein, about $0.01 \leq (Y/Z) \leq$ about 0.3;</i>	See Section XIII.B.7 above regarding element [1.7].
[14.8]	<i>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.</i>	See Section XIII.B.8 above regarding element [1.8].
Claim 15		
Element	Text	Reasoning
[15.1]	<i>The electrochemical device according to claim 14, wherein the first electrode is a cathode, the second electrode is a cathode, and $3.5 \text{ g/cm}^3 \leq D2 \leq 4.3 \text{ g/cm}^3$.</i>	See Section XIII.C above regarding element [2.1].

Claim 17		
Element	Text	Reasoning
[17.1]	<i>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-dioxapimelonitrile, 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-hexaoxaeicosanoic 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-</i>	See Section XIII.E above regarding element [5.1].

	<i>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.</i>	
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246. Accordingly, in my opinion, Zhou and Sunose render obvious claims 14-17.

XIV. GROUND 4A: ZHOU AND SUNOSE, FURTHER IN VIEW OF SU, RENDER OBVIOUS CLAIMS 3 AND 16

247. To the extent the Zhou/Sunose combination does not disclose all elements of claims 3 and 16, in my opinion Zhou/Sunose further in view of Su renders claims 3 and 16 obvious.

A. Claim 3

1. **[3.1] “The electrochemical device according to claim 1, wherein the electrode is an anode, and”**

248. In my opinion, Zhou discloses or suggests this claim element. *Supra* Section XIII.B.2.

2. **[3.2] “ $1.2 \text{ g/cm}^3 \leq D2 \leq 1.8 \text{ g/cm}^3$.”**

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

249. Zhou and Sunose do not disclose these elements but, as discussed above, Su does. *Supra* Section X.A.1.b. In my opinion, for the same reasons

discussed in Ground 2A, it is my opinion that a POSITA would have found it obvious to configure Zhou's anode electrode according to Su's Examples with a reasonable expectation of success. Zhou, Sunose, and Su are directed to analogous art—lithium-ion batteries, including those using non-aqueous electrolytes. See EX1014, ¶ [0006]; EX1010, Abstract, ¶¶ [0001]-[0011], [0043], [Claim 3]; EX1012, Abstract, ¶¶ [0001]-[0003]. Like Zeng, Zhou also expresses a market demand for batteries with high energy density. EX1014, ¶¶ [0002]-[0005]. Thus, in my opinion, Zhou, Sunose, and Su render claims 3 and 16 obvious.

XV. GROUNDS 3C, 4C: ZHOU/SUNOSE, FURTHER IN VIEW OF KIM, RENDER OBVIOUS CLAIMS 1, 2, 4-7, 12, 14, 15, AND 17; ZHOU/SUNOSE/SU, FURTHER IN VIEW OF KIM, RENDER OBVIOUS CLAIMS 3 AND 16

250. In my opinion, for the reasons discussed above in Grounds 1C and 2C, Kim further motivates considering the ratio of trinitrile to PP in Zhou and substituting EA for PP in Zhou Example 8.¹¹ *Supra* Section XII. In my opinion, Zhou draws further attention to the advantage of a trinitrile (HTCN) by explaining that it has “[a high] density of nitrile groups per unit volume” and “better

¹¹ For all Challenged Claim elements other than Elements [1.7] and [14.7], I incorporate by reference my analysis for those claim elements in Grounds 3A and 4A.

compatibility with the negative electrode and is easier to protect the positive electrode.” EX1014, ¶ [0059]. Zhou also discloses substituting EA with PP for, drawing attention to PP. *Id.*, ¶ [0011]. Zhou also cautions the POSITA against using an “excessive” amount of PP because it “has a negative effect on the cycle performance,” focusing attention on Y/Z. *Id.*, ¶ [0059].

251. For these additional reasons, in my opinion, Zhou and Sunose, further in view of Kim, render obvious claims 1, 2, 4-7, 12, 14, 15, and 17 (Ground 3C), and Zhou, Sunose, and Su, further in view of Kim render obvious the Challenged Claims 3 and 16 (Ground 4C).

XVI. CONCLUSION

For these reasons, it is my opinion that the Challenged Claims of the '131 Patent are unpatentable.

I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I could testify to the matters in this declaration competently if called upon to do so. I further declare 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 the Title 18 of the United States Code.

Date: January 28, 2025

Respectfully Submitted,

A handwritten signature in black ink, appearing to read 'Brett Lucht', written over a horizontal line.

Brett Lucht, Ph.D.