

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LG ENERGY SOLUTION, LTD.,
Petitioner

v.

MOLECULAR REBAR DESIGN, LLC,
Patent Owner

Case IPR2024-01011
U.S. Patent 8,968,924

PATENT OWNER'S RESPONSE

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EXHIBIT LIST

Exhibit No.	Description
MRD-2006	Declaration of Dr. Deborah D.L. Chung, Ph.D.
MRD-2007	WEBSTER'S NEW WORLD COLLEGE DICTIONARY (4th ed. 1999), various definitions
MRD-2008	U.S. Patent No. 8,703,009 ("Liu-009")
MRD-2009	Mengxuan Zhang et al., <i>Binder Assisted Dispersion of Agglomerated Carbon Nanotubes for Efficiently Establishing Conductive Networks in Cathodes of Li-Ion Batteries</i> , 8 ENERGY TECHNOLOGY 2000589 (2020).
MRD-2010	Varrla Eswaraiah et al., <i>Morphological, Thermal, Electrical and Electromechanical Properties of Polyvinylidene Fluoride (PVDF)-Functionalized Carbon Nanotube Composites (Preprint)</i> , AFRL-RX-WP-TP-2012-0277 INDIAN INSTITUTE OF TECHNOLOGY CHENNAI (2012).
MRD-2011	B. V. Bahaskara Rao et al., <i>Fabrication and Evaluation of Thin Layer PVDF Composites Using MWCNT Reinforcement: Mechanical, Electrical and Enhanced Electromagnetic Interference Shielding Properties</i> , 6 AIP ADVANCES 065107 (2016).
MRD-2012	Viraj Bhingardive et al., <i>Polyvinylidene Fluoride Based Lightweight and Corrosion Resistant Electromagnetic Shielding Materials</i> , 5 RSC ADV. 35909 (2015).
MRD-2013	Ming Wang et al., <i>The Influence of Polyvinylidene Fluoride (PVDF) Binder Properties on $\text{LiNi}_{0.33}\text{Co}_{0.33}\text{Mn}_{0.33}\text{O}_2$ (NMC) Electrodes Made by a Dry-Powder-Coating Process</i> , 166 JOURNAL OF THE ELECTROCHEMICAL SOCIETY A2151 (2019).

Exhibit No.	Description
MRD-2014	Soumyaranjan Mishra et al., <i>Synthesis of PVDF/CNT and Their Functionalized Composites for Studying Their Electrical Properties to Analyze Their Applicability in Actuation & Sensing</i> , 509 COLLOIDS AND SURFACES A: PHYSICOCHEMICAL AND ENGINEERING ASPECTS 684 (2016).
MRD-2015	U.S. Patent No. 6,869,724
MRD-2016	Lizhi Wen et al., <i>Effect of Conductive Material Morphology on Spherical Lithium Iron Phosphate</i> , 8 NANOMATERIALS 904 (2018).
MRD-2017	U.S. Patent Application Publication No. 2014/0319429 (“Nicolas-429”)
MRD-2018	U.S. Patent Application Publication No. 2011/0256454 (“Nicolas-454”)
MRD-2019	RESERVED
MRD-2020	Wener Bauer et al., <i>Rheological Properties and Stability of NMP Based Cathode Slurries for Lithium Ion Batteries</i> , 40 CERAMICS INTERNATIONAL 4591 (2013).
MRD-2021	RESERVED
MRD-2022	RESERVED
MRD-2023	Declaration of Dr. Yu Zhu in IPR2024-01013, dated June 12, 2024
MRD-2024	Deposition Transcript of Dr. Yu Zhu in IPR2024-01013, dated March 14, 2025
MRD-2025	Deposition Transcript of Dr. Yu Zhu in IPR2024-01006, dated March 21, 2025
MRD-2026	Deposition Transcript of Dr. Yu Zhu in IPR2024-01011, dated March 21, 2025

Exhibit No.	Description
MRD-2027	RESERVED
MRD-2028	U.S. Patent Application Publication No. 2024/0274804
MRD-2029	Niurka Barrios-Bermúdez et al., <i>Amino-Functionalized Multiwall Carbon Nanotubes as Efficient Basic Catalysts for the Formation of γ-Lactams: Synthesis of N-1-Heptenyl-2-pyrrolidinone</i> , 12 NANOMATERIALS 684 (2022).
MRD-2030	Shankhamala Kundu et al., <i>Thermal Stability and Reducibility of Oxygen-Containing Functional Groups on Multiwalled Carbon Nanotube Surfaces: A Quantitative High-Resolution XPS and TPD/TPR Study</i> , 112 J. PHYS. CHEM. 16869 (2008).
MRD-2031	S.A. Chernyak et al., <i>Mechanism of Thermal Defunctionalization of Oxidized Carbon Nanotubes</i> , 120 THE JOURNAL OF PHYSICAL CHEMISTRY 17465 (2016).
MRD-2032	Nathan Hordy et al., <i>Thermal Stability of Plasma Generated Oxygenated Functionalities on Carbon Nanotubes</i> , 12 PLASMA PROCESS. POLYM. 533 (2015) 533.
MRD-2033	ICSC: 1577 – FERRIC OXIDE (2004)
MRD-2034	Haitao Wang et al., <i>In Situ TiC-Reinforced Ni-Based Composite Coating Prepared by Flame Spraying Using Sucrose as the Source of Carbon</i> , 18 JOURNAL OF THERMAL SPRAY TECHNOLOGY, 103 (2009).
MRD-2035	RESERVED
MRD-2036	RESERVED
MRD-2037	Aleksander Cholewinski et al., <i>Polymer Binders: Characterization and Development toward Aqueous Electrode Fabrication for Sustainability</i> , 13 POLYMERS 631 (2021).

Exhibit No.	Description
MRD-2038	Xiaoping Shui et al., <i>High-Strength High-Surface-Area Porous Carbon Made From Submicron-Diameter Carbon Filaments</i> , (2016).
MRD-2039	RESERVED
MRD-2040	R. Piat et al., <i>Identification of Coefficients of Thermal Expansion of Pyrolytic Carbon with Different Texture Degrees</i> , 251-252 KEY ENGINEERING MATERIALS 333 (2003).
MRD-2041	Keiichi Shirasu et al., <i>Negative Axial Thermal Expansion Coefficient of Carbon Nanotubes: Experimental Determination Based on Measurements of Coefficient of Thermal Expansion for Aligned Carbon Nanotube Reinforced Epoxy Composites</i> , 95 CARBON 904 (2015).
MRD-2042	Tobias Gensch et al., <i>Approach to Comparing Functional Group Tolerance of Reactions</i> , 82 THE JOURNAL OF ORGANIC CHEMISTRY 9154 (2017).

I. Introduction

Patent Owner presents substantial new evidence and arguments demonstrating that Petitioner fails to carry its burden of proving unpatentability of any claim.

Ohata-Kavan (Ground 1) has been asserted by Petitioner in this and two other IPR proceedings (IPR2024-01006 and IPR2024-01013). However, the combination is fundamentally flawed for several reasons common to all three proceedings. *Infra* Section V.

Cheng-Gan (Ground 2) is only asserted in this proceeding but equally flawed nonetheless. *Infra* Section VI. First, Cheng-Gan does not teach or render obvious the claimed oxidation levels, because the combination calcines the oxidized carbon nanotubes at a temperature of 600 C°+ for 4+ hours. This would remove essentially all oxidation and discourage a POSITA from even considering oxidizing. *Infra* Section VI.B.1-3. Second, Cheng-Gan does not achieve “discrete” CNTs, but instead seeks to achieve the opposite—i.e., an *interconnected* network of CNTs to improve electrical conductivity. *Infra* VI.B.4-5.

II. Level of Ordinary Skill

Patent Owner applies Petitioner’s proposed definition of a POSITA for purposes of this proceeding only. Patent Owner’s technical expert, Dr. Deborah Chung, has a Bachelor’s Degree in Engineering and Applied Science and a Master’s Degree in Engineering Science from the California Institute of Technology. MRD-

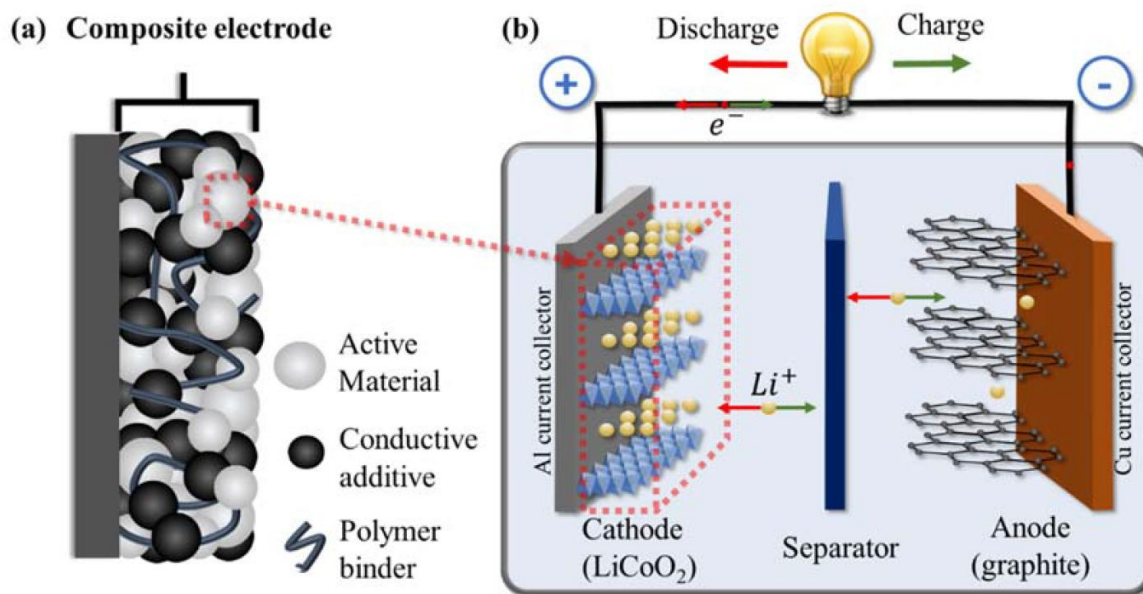
2006 ¶4. Dr. Chung also has a Master's Degree in Materials Science and a Doctorate in Materials Science from the Massachusetts Institute of Technology. *Id.* A central focus of Dr. Chung's decades of technical experience has been studying CNTs. *Id.* ¶¶6-17. Thus, Dr. Chung qualifies as a POSITA. *Id.* ¶49-51.

III. Overview of Technology

The '924 Patent is directed toward lithium-ion batteries, particularly compositions that makeup the electrode (either the cathode or anode) of lithium-ion batteries. LGES-1001, 2:37-47.

A. Overview of Electrodes

In reference to the schematic below, an electrode (cathode or anode) comprises three key parts: (1) the active material, (2) a binder, and (3) a conductive additive. MRD-2037, 2. The depicted cathode is on a current collector:



Id. The active material (1) is the electrochemically active component that directly participates in the reactions that allow the battery to store and release energy, which involves the active material expanding and contracting during charging and discharging. MRD-2006 ¶58.

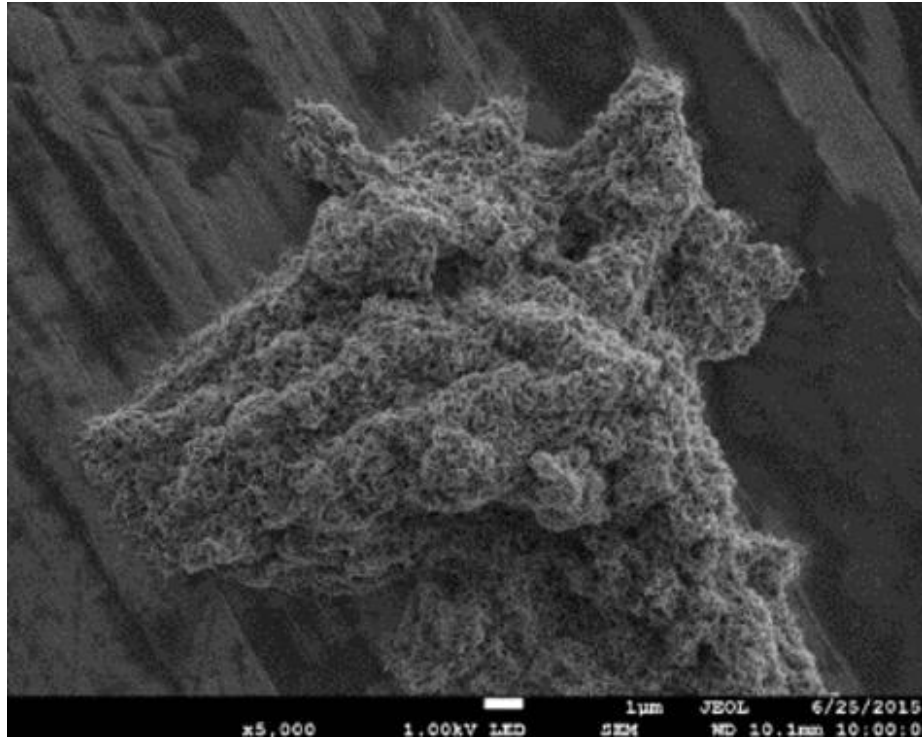
The binder (2) acts as a “glue” to hold the active material particles together, as well as to attach the active material to the current collector, providing mechanical strength to the composite as a whole. *Id.* ¶59.

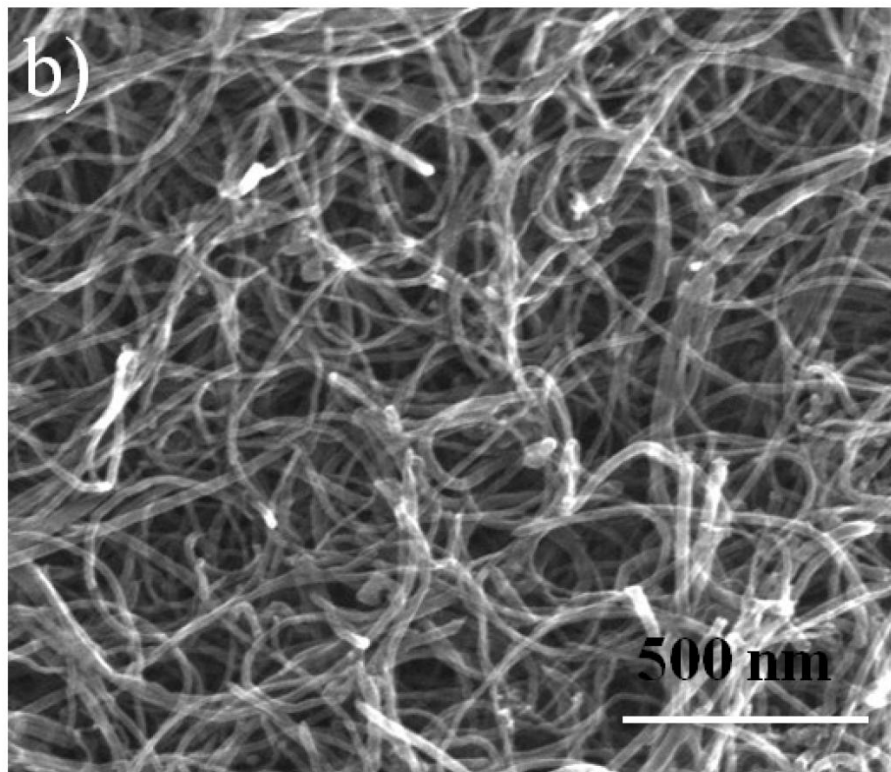
A conductive agent (3) is typically included in the electrode composition to help provide a continuous, electrically conductive path in the electrode composition between the active material, improving conductivity. *Id.* ¶¶60-61.

B. Efforts to Improve Electrical Conductivity

At the time of the invention, it was common to use carbon black as the conductive agent to try and form a continuous conductive network in lithium-ion battery electrodes. *Id.* ¶62 (citing LGES-1004 ¶¶[0002]-[0003]). However, CNTs were of particular interest because of their high electrical conductivity and mechanical strength relative to carbon black, making them prime candidates for use as conductive agents. *Id.* ¶¶62-63 (citing LGES-1007 ¶¶[0005]-[0006], [0009]). However, one of the key challenges with CNTs is that they are created as highly entangled bundles (“raw” bundles). *Id.* ¶63. Scanning electron microscopy (“SEM”)

images are provided below as an example of how CNTs present as a highly entangled mass in their raw state:





Id. (citing MRD-2010, 15, Fig. 2(b)).

This excessive bundling presented several problems, including higher resistance due to the number of CNT-to-CNT contact points and considerable difficulty in dispersing the CNTs throughout the electrode composition. *Id.* ¶64. The inability to adequately disperse CNTs throughout the electrode composition can result in agglomeration, leading to local discontinuities (e.g., voids) in the conductive network of the composition. *Id.* (citing MRD-2019 ¶[0027]).

At the time of the invention, a key focus of those seeking to leverage CNTs as a conductive agent was trying to form the most effective continuous (also called “percolated”) conductive network. *Id.* ¶¶65-66 (citing LGES-1007 ¶¶[0005], [0009]-

[0010] (hereafter “Cheng”); LGES-1021 ¶[0041] (hereafter “Gan”)). Figure 5 of Gan depicts CNTs that have been dispersed to form a “continuous” or “percolated” CNT network:

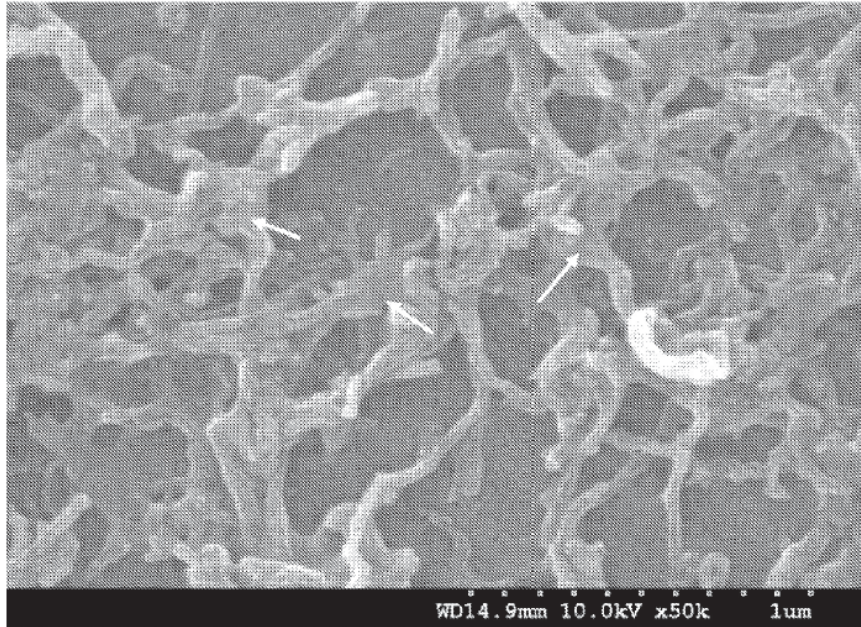


FIG.5

Id.; MRD-2010, 12 (explaining that “electrons can travel easily from one tube to another tube without any obstacle” when touching). To achieve these continuous networks of CNTs, a primary goal was to disentangle them to improve their dispersion, resulting in a CNT network that is better distributed throughout the overall composition. MRD-2006 ¶66 (citing LGES-1021 ¶[0019]-[0021]; LGES-1007 ¶[0010]).

C. The '924 Patent

While the conventional wisdom at the time was to achieve a network of interconnected CNTs (i.e., a “continuous” network) between active material particles, the inventors made the unconventional discovery that discrete CNTs provide major advantages when the active material crystals are attached (e.g., ionically or covalently bonded) to the surface of the CNTs via oxidation. *Id.* ¶67 (citing LGES-1001, 1:52-64). As the Patent explains, “discrete” CNTs are those that are individually dispersed and separate from other CNTs. *Id.* (citing LGES-1001, 1:45-49 (describing “discrete carbon nanotubes” as “individual uniformly dispersed tubes”), 3:52-54 (explaining that “discrete carbon nanotubes” refers to CNTs being “separated to give individual tubes”), FIG. 1 (depicting individual tubes separate from any other tube); MRD-2007, 8 (defining “discrete” as “separate and distinct; not attached to others; unrelated”); MRD-2024, 11:4-8 (Dr. Zhu testifying that CNTs are discrete “because” they are “fully isolated” from one another), 12:17-13:22 (testifying that “discrete” CNTs are “separated from each other”); MRD-2025, 11:7-12:1.

The inventors discovered that the microcracking of active material crystals—due to expansion/contraction during charging/discharging—could be “retarded” by binding the active material crystals to the surface of discrete CNTs. *Id.* ¶68 (citing LGES-1001, 1:52-63). These discrete CNTs provide mechanical strength to prevent

cracking from occurring. *Id.* Additionally, they can bridge across fractured parts of active material, more freely interact with active material than interconnected CNTs that form a continuous network, and be used instead of carbon coatings having numerous drawbacks. *Id.* (citing MRD-2028 ¶[0042]; LGES-1001, 1:64-2:8).

Thus, while those in the art at the time were seeking to achieve a continuous network of CNTs for electrodes, the inventors ***took the opposite approach by seeking to achieve discrete CNTs*** with active material attached to their surfaces. *Id.* ¶69. This provides numerous improvements, including “improved capacity, electron and ion conductivity and mechanical strength,” “support and spatial stabilization of” active material particles, “improved heat transfer media to avoid thermally-induced runaway,” “structural strength to the paste during manufacturing and high surface area per weight of” active material “to provide good energy density.” *Id.* (quoting LGES-1001, 2:9-28. “The uniform dispersion of discrete tubes will also provide a more uniform voltage gradient...” *Id.* (quoting LGES-1001, 2:29-33).

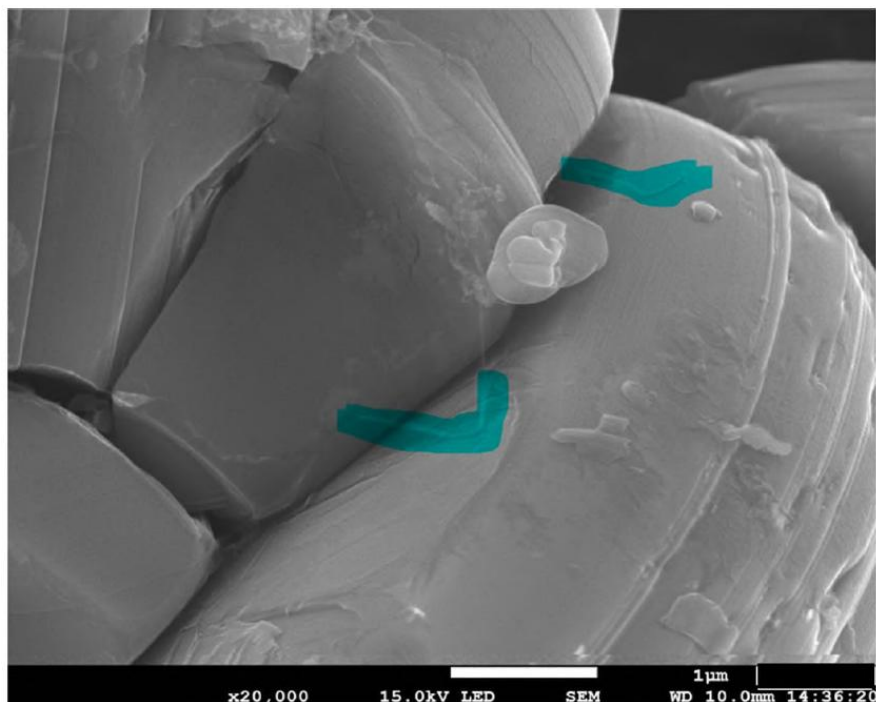
The specification explains that “[d]uring the process of making discrete carbon nanotubes ..., the nanotubes are cut into segments and the residual catalyst particles ... are dissolved.” LGES-1001, 4:4-11. Cutting of the tubes “helps with exfoliation,” which refers to disentangling as between CNTs so that they can be separated or isolated from one another. MRD-2006 ¶70. The inventors also explain that “[p]roper selection of the carbon nanotube feed stock” allows more control in

achieving discrete CNTs” and that the preferred selection “is where the internal catalyst sites are evenly spaced.” *Id.* (quoting LGES-1001, 4:11-19).

After applying this unique process, CNTs having an aspect ratio of 10-500 are oxidized to add functional groups to their surface, and the oxidized CNTs are mixed directly with an active material (along with other materials), so that the active material can attach to the added functional groups. *Id.* ¶71 (citing LGES-1001, 4:47-62). In every example, the surface of the oxidized CNTs is fully exposed to the active material, which allows for the active material to form a strong bond to the surface of the CNTs via the added functional groups. *Id.* (citing LGES-1001, 5:9-7:5).

The '924 Patent thus discloses a novel process for creating well-dispersed, discrete, oxidized CNTs with active material particles attached to their surface, which among other things reduces retardation of the active material crystals. *Id.* ¶72. While improved dispersibility is one factor for achieving discrete CNTs, dispersibility and discreteness are fundamentally difference concepts. *Id.* Indeed, much of the cited prior art focuses heavily on improved dispersibility to achieve a **continuous** network of CNTs, which are by definition, not discrete because they are interconnected. *Id.* The inventors' discovery—discrete CNTs having active material attached their surface, and the benefits associated therewith—ran contrary to this conventional wisdom and is now being used throughout the lithium-ion battery industry. *Id.* For example, LGES and Samsung rely on discrete CNTs (blue) to retard

cracking of active material crystals in their lithium ion batteries:



LGES-1033, 32. This is fundamentally different than the prior art concept of interconnecting CNTs to form a continuous or percolated conductive network between active material particles. MRD-2006 ¶72.

IV. Claim Construction

The Board is required to construe “only those terms ... that are in controversy, and only to the extent necessary to resolve the controversy.” *Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1375 (Fed. Cir. 2019). Because Petitioner fails to demonstrate unpatentability pursuant to its own application of the claim language, no construction is required.

V. Ground 1: Ohata-Kavan Does Not Render Any Claim Unpatentable.

A. Independent Claim 1

Petitioner acknowledges that Ohata does not disclose oxidized CNTs. Pet., 12. To account for this feature, Petitioner argues that it would have been obvious to oxidize the CNTs of Ohata (pursuant to Kavan) and then use the oxidized CNTs to create the “masterbatch” of Ohata. *Id.* Petitioner further argues that it would have been obvious to then use the masterbatch to produce electrode material mixture pastes pursuant to Ohata but using LiFePO_4 or LiMnPO_4 for the positive electrode (as taught by Kavan). *Id.* Petitioner argues that a POSITA would have been motivated to oxidize the CNTs of Ohata when used with these active materials, because it would provide several benefits, such as allowing the active materials to attach to the CNTs’ functional groups. *See id.*, 13-15. However, Petitioner improperly ignores critical teachings from Ohata that wholly undermine its assertion that the combination possesses all limitations of the challenged claims and the alleged motivations to combine.

Petitioner repeatedly states that the purpose of Ohata’s “masterbatch” is to “unravel[] and straighten[]” the CNTs by blending them with a resin. *Id.*, 10, 12, 14, 22. However, Petitioner simply ignores, or perhaps overlooks, that Ohata also clearly teaches that the “masterbatch” is the binder for the electrodes of its lithium-ion

batteries. *Infra* Section V.A.1. Such binder acts as a viscous “glue” that binds the active material particles together, providing increased mechanical strength during handling, charging, and discharging. Ohata recognizes, however, that resin binders are poorly conductive but can be improved by embedding CNTs within the binder particles. Thus, Ohata proposes creating a binder via its masterbatch process, where the “proper amount of the carbon nanotubes contained in the masterbatch is 5 to 20 parts *by weight per 100 parts by weight of the resin.*”¹ LGES-1004 ¶[0006]. Consequently, in Ohata, the masterbatch *is* the binder. It is only *after* the CNTs are embedded in the resin binder that the active material is mixed with the masterbatch. This fact fundamentally undermines the Ohata-Kavan combination.

First, the active materials of Ohata-Kavan cannot be “attached to the[] surface” of the oxidized CNTs as required by claim 1. *Infra* Section V.A.2. The masterbatch process of Ohata-Kavan results in CNTs *fully embedded within, and coated by, the fluorocarbon resin matrix*, preventing the later mixed active material from attaching to the CNT surfaces. In fact, CNTs and fluorocarbon resin have an affinity toward one another, ensuring full coverage of the CNT surfaces with the resin. This design is purposeful in Ohata, because the masterbatch, with its high concentration of resin as compared to the concentration of CNTs, *is the binder* for

¹ All emphasis is added unless otherwise indicated.

the active material. As such, even assuming the active material is “attached” to the surface of the oxidized CNTs in Kavan *alone*, the same cannot be said of ***Ohata-Kavan***.

Second, there would have been no motivation to oxidize the CNTs pursuant to Kavan, as the benefits of oxidation described by Kavan only apply if the CNT surfaces *are exposed* to the active material. *Infra* Section V.A.3. Indeed, there is no rationale for oxidizing CNTs to add functional groups to facilitate attachment to the active material (as taught by Kavan), only to then turn around and cover those functional groups in resin to prevent attachment.

Third, Petitioner fails to demonstrate a reasonable expectation of success in achieving the claimed invention. *Infra* Section V.A.4. There would have been no expectation of achieving discrete CNTs with active material “attached to their surface” given that the CNTs are covered in resin.

Fourth, Ohata-Kavan does not teach “discrete” CNTs. *Infra* Section V.A.5. To the contrary, Ohata-Kavan seeks to achieve a *continuous* network of CNTs to improve electrical conductivity, which would have been understood to be fundamentally undermined by the goal of discrete CNTs.

1. Petitioner overlooks the critical fact that the “masterbatch” process embeds the CNTs in resin to form the binder.

Petitioner vaguely describes Ohata as preparing “composites of carbon

nanotubes and either positive or negative electrode active materials for use as electrodes in lithium ion batteries.” Pet., 9. However, Ohata is doing something more specific and significant to the issues here—Ohata is creating an improved resin binder by **embedding CNTs within the resin matrix** to form its masterbatch. MRD-2006 ¶74 (citing LGES-1004 ¶¶[0005]-[0006], [0030]); MRD-2024, 58:5-10 (admitting Ohata is “embedding” conductive material “within the resin”). It is only *after* the CNTs are embedded in the masterbatch resin that they are *then* mixed with the active material to prepare the electrodes for the battery. *Id.* (citing LGES-1004 ¶¶ [0005], [0032], [0046]). This is clear from the plain teachings of Ohata.

In the “Background of the Invention,” Ohata explains that it was known to mix an “active material with a conductive material and **a binder** to form a paste,” but that if the amount of conductive material is large “battery capacity will be decreased.” LGES-1004 ¶[0002]. To address this drawback, Ohata teaches that it was known to perform “a masterbatch process, whereby a conductive material [e.g., carbon black] is uniformly predispersed **in a binder**, in the production of a positive electrode” *Id.* In other words, the “conductive material” is predispersed in the “binder” to create a more conductive **binder**. MRD-2006 ¶76. The binder is then mixed with the active material to bind the active material together as part of an electrode mixture material paste. *Id.* A POSITA would understand that binders typically have low electrical conductivity, and that embedding a conductive material

(e.g., carbon black) in the binder matrix increases its conductivity. *Id.* ¶77. Thus, the term “masterbatch” as used in Ohata, refers to **a binder** with embedded conductive material. *Id.* ¶76.

U.S. Patent No. 8,703,009 (MRD-2008, “Liu-009”) provides an example of the type of conductive glue-like “masterbatch” process that Ohata describes. *Id.* ¶78. Figure 6 below is a “cartoon” from Liu-009 showing “how ... active material is glued together by conductive glue” comprising carbon black embedded in polyvinylidene fluoride (“PVDF”) resin. *Id.* (quoting MRD-2008, 4:16-17, 6:25-29 11:28-32); MRD-2024, 33:21-34:1.

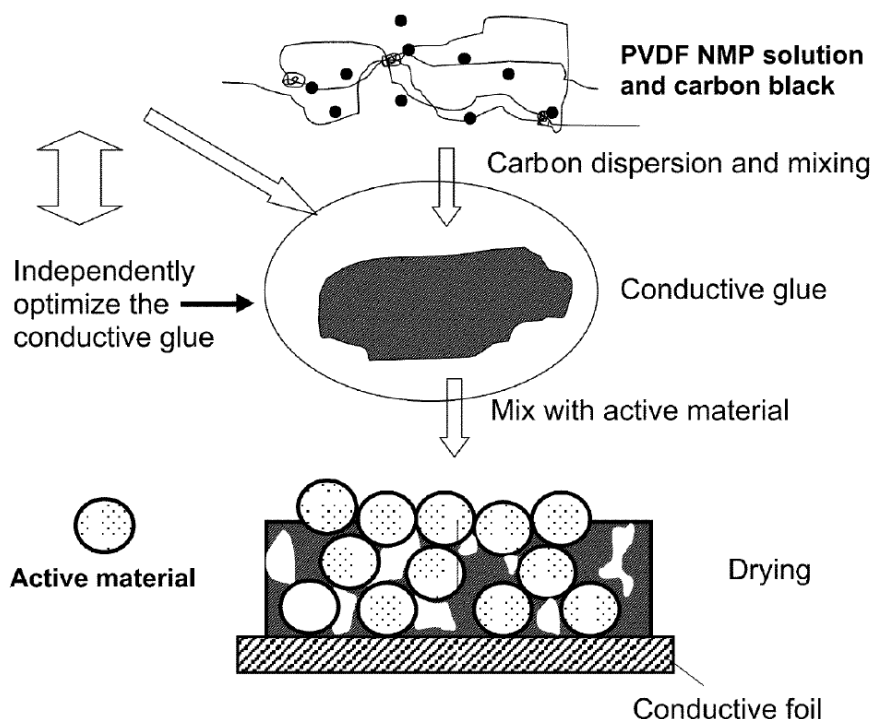


FIG. 6

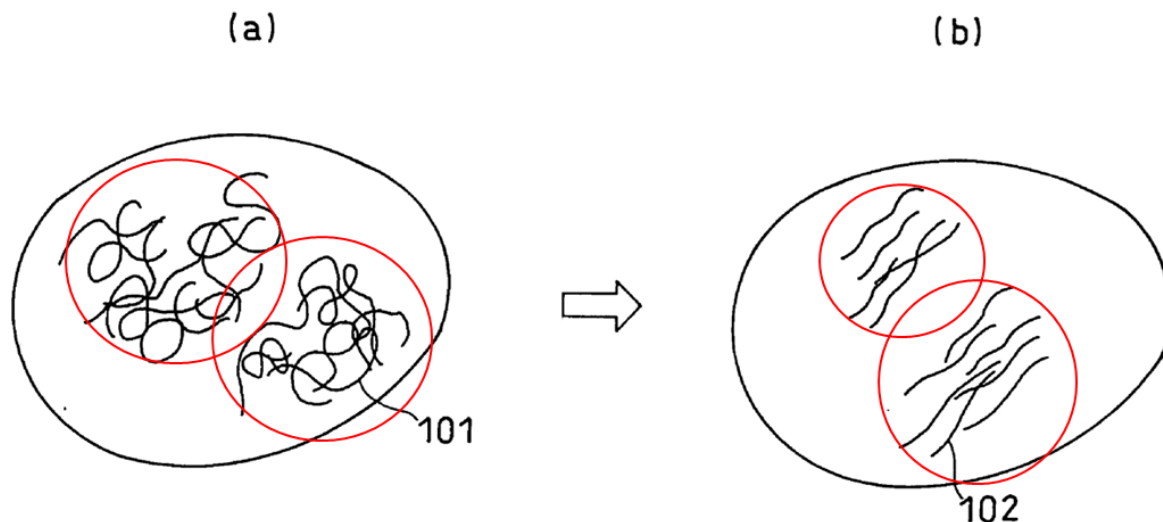
Ohata teaches that in a masterbatch comprising carbon black and powdered graphite, the primary particles “are linked into a chain to form a conductive path,” which “is likely to be damaged by shearing force” during the masterbatch process. LGES-1004 ¶[0003]. In other words, the carbon black and powdered graphite are chained together to form a continuous conductive network within the binder, but that improvement is limited because the carbon black network can break during blending. MRD-2006 ¶79 (citing LGES-1004 ¶[0003]). “For this reason, the use of the masterbatch process to uniformly disperse the conductive material *in a binder* does not yield an electrode superior in conductivity.” LGES-1004 ¶[0003]. Thus, the problem Ohata is attempting to overcome is the breakage of conductive chains of carbon black in a binder. MRD-2006 ¶¶80-81.

“In view of this” drawback, Ohata prepares its own “masterbatch” comprising a large amount of resin and small amount of CNTs. LGES-1004 ¶¶[0004]-[0005]. “Unlike carbon black and powdered graphite, a conductive path to be formed by carbon nanotubes is not damaged by shearing force,” allowing “an electrode superior in conductivity.” *Id.* ¶[0015]. Thus, Ohata teaches that it is attempting to create an improved conductive binder (“masterbatch”) by predispersing electrically conductive CNTs in the resin. MRD-2006 ¶¶82-84. The binder is then further mixed with an electrode active material to bind the active material together and form an electrode active material paste. *Id.* ¶84 (citing LGES-1004 ¶¶[0005], [0023]).

Consistent with these teachings, the first step in all embodiments of Ohata is to prepare the “masterbatch,” which is “5 to 20 parts by weight [of CNTs] per **100 parts by weight of the resin.**” *Id.* ¶85 (quoting LGES-1004 ¶¶[0005]-[0006]). In other words, the lowest end of the range is 5% by weight of CNTs to 95% by weight of resin and the highest is 20% by weight of CNTs to 80% by weight of resin. *Id.* Thus, resin makes up the overwhelming majority of the masterbatch binder. *Id.*

In reference to annotated cartoon Figure 1(a) depicting two groups (red circles) of CNTs, Ohata teaches that “carbon nanotubes 101 are tangled and twisted with one another before they are blended with a resin” as part of the masterbatch process. LGES-1004 ¶[0016]. Ohata contends that during the masterbatch process, the CNTs are “unraveled and straightened by blending them with a resin, as shown in FIG. 1(b).” *Id.*

FIG. 1



Thus, one of the purposes of blending CNTs with resin is to unravel and straighten them because they are “expected to form an excellent conductive path,” “serve[] to increase the mechanical strength of the electrode plate,” and may “produce a secondary battery excellent in cycle characteristics.” MRD-2006 ¶¶86-87 (quoting LGES-1004 ¶¶[0016]-[0017], [0021]). However, the *other* important reason for the masterbatch process is to use the masterbatch as a binder with embedded conductive material (i.e., the CNTs). *Id.* ¶87.

Although Ohata provides 15 examples of a positive and/or negative electrode prepared using the masterbatch, **Example 1** serves as the basis for most examples. *Id.* ¶88. In that example, the masterbatch is prepared by blending 15 parts by weight of CNTs and **85 parts by weight of PVDF** using an extruder. *Id.* ¶89 (citing LGES-

1004 ¶[0030]). The masterbatch—again consisting largely of resin—is then used to prepare a “positive electrode material mixture paste” by mixing 3.3 parts by weight of the masterbatch with LiCoO_2 as an active material with 45 parts by weight of N-methyl-2-pyrrolidone (“NMP”), which is used to disperse the masterbatch into the mixture paste. *Id.* (citing LGES-1004 ¶¶[0030], [0032]). Ohata does not teach mixing additional resin with the positive electrode material mixture in this example, but instead relies solely on the masterbatch as the binder. *Id.*

The negative electrode is also created, but without using the masterbatch at all. *Id.* ¶90 (citing LGES-1004 ¶[0034]). Instead, “3 parts by weight of styrene butadiene rubber” is used “as a binder.” *Id.* Thus, in Example 1 the positive electrode uses the masterbatch as the binder and the negative electrode uses a different resin binder. *Id.* This is because the masterbatch *is the binder* in the positive electrode example, while a different binder is used for the negative electrode. *Id.*

Examples 2 to 8 follow Example 1, except for the differences reflected in Table 1. *Id.* ¶91 (citing LGES-1004 ¶[0040]). Thus, these examples also include a masterbatch comprising at least 80 parts resin and at least 15 parts CNTs. *Id.*

Example 9 follows Example 1, except that vinylidene fluoride-hexafluoropropylene copolymer is used as a resin for the masterbatch instead of PVDF. *Id.* ¶92 (citing LGES-1004 ¶[0041]).

Examples 10 to 14 follow Example 1, except that the CNTs have different

diameters and aspect ratios as reflected in Table 2. *Id.* ¶93 (citing LGES-1004 ¶[0042]).

Example 15 prepares a negative electrode using the same masterbatch from Example 1. *Id.* ¶94 (citing LGES-1004 ¶[0046]). The corresponding positive electrode is created using PVDF alone as the binder, instead of the masterbatch. *Id.* (citing LGES-1004 ¶[0044]).

Ohata thus teaches that its “masterbatch” is ***a binder with embedded CNTs*** that is used to hold the active material together. *Id.* ¶95. The process of Ohata is fundamentally different than the process of Kavan. *Id.* ¶96. Unlike Ohata, Kavan does not (i) immerse its oxidized CNTs in resin to form a binder as an initial step and (ii) ***then*** mix the resin-covered CNTs with the active materials. *Id.* Instead, Kavan prepares a “powder precursor material” by first mixing its oxidized CNTs with *water* and an active material powder and stirring overnight, which leaves the CNT surfaces exposed (or “naked”) ***so that the active material can attach to their surfaces to achieve the benefits described by Kavan.*** *Id.* (citing LGES-1005, 2). Thus, in Kavan, the naked oxidized CNTs and active material are pre-mixed into a powder ***before*** mixing that powder with the PVDF binder, so that the active material can take advantage of the functional groups of the oxidized CNTs by “anchoring.” *Id.* ¶97. Likewise, the ’924 Patent mixes naked oxidized CNTs with the active material in all examples for this same reason. *Id.* (citing LGES-1001,5:9-7:5).

In contrast, Ohata believed that dispersing the naked CNTs with the active material is “difficult taking the dispersibility of the carbon nanotubes in the resin into consideration.” *Id.* ¶98 (quoting LGES-1004 ¶[0021]). Thus, Ohata chose a fundamentally different approach to dispersibility that involved first **embedding the CNTs in the resin** binder and **then** mixing the binder with the active material to achieve better dispersion. *Id.* This indisputable fact is problematic for Petitioner’s Ohata-Kavan combination as further explained below.

2. Petitioner fails to demonstrate that Ohata-Kavan teaches or renders obvious “ion active material attached to their [carbon nanotubes] surface.”

Petitioner alleges that Ohata-Kavan results in CNTs with ion active material that is “**attached to the[] surface**” of the CNTs. Pet., 26. Specifically, Petitioner argues that LiMnPO_4 and LiFePO_4 are ion active materials and that the CNTs in the combination electrode material paste have “phosphate olivine crystals that are attached to the nanotube surface due at least in part to the surface oxidation of the nanotubes.” Pet., 25-26. Petitioner cites Kavan to support both assertions. *Id.* Petitioner thus relies on the teachings of **Kavan alone** to support its position that the active material **of Ohata-Kavan** is “attached to the[] surface” of the CNTs. MRD-2006 ¶99. However, as explained in Section V.A.1 above, there is a critical difference between how Kavan **alone** and the Ohata-Kavan **combination** prepare their electrode material mixtures. *Id.* ¶100.

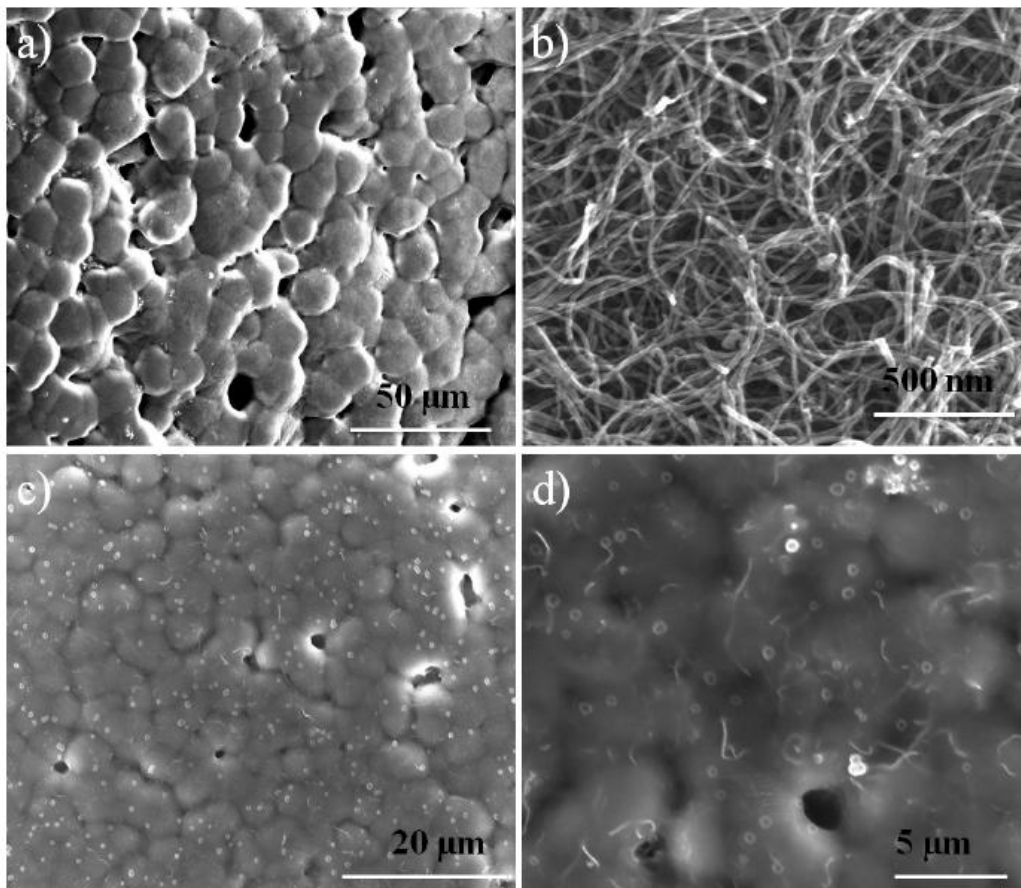
In Ohata-Kavan, Petitioner begins with the masterbatch process **to initially create a binder with embedded CNTs** as taught by Ohata. Pet., 11. Kavan, on the other hand, does not teach or suggest any form of masterbatch process, and certainly does not fully immerse its nanotubes in resin like Ohata. MRD-2006 ¶¶101-102. Instead, Kavan mixes its naked oxidized CNTs with active material and water, so that that the CNTs are fully exposed to the active material to allow the active material to attach to the functional groups of the CNTs. *Id.* ¶102 (citing LGES-1005, 2).

It is Petitioner's burden to demonstrate that Ohata-Kavan teaches ion active materials "attached to the[] surface" of oxidized discrete CNTs. However, Petitioner fails to account for the Ohata-Kavan "masterbatch" fully immersing and blending the CNTs in fluorocarbon resin as an initial step **to form the binder** for the electrode material mixture paste. *Id.* ¶103. Instead, Petitioner appears to believe that the only reason Ohata is creating the masterbatch is to straighten and unravel the CNTs. Pet., 10, 12, 14, 22; *see also* MRD-2024, 42:25-44:22 (Dr. Zhu failing to acknowledge that the purpose of the masterbatch is to serve as binder). However, when Ohata is read in context and for all that it teaches, it is indisputable that the primary purpose of the masterbatch is to act as the binder that holds the active material together. MRD-2006 ¶103; *Artic Cat Inc. v. Bombardier Rec. Prods.*, 876 F.3d 1350, 1360 (Fed. Cir. 2017). This oversight is fatal to all grounds, because the masterbatch process results in resin coating the surface of the oxidized CNTs, preventing the

active material from “attaching to the surface.” MRD-2006 ¶104.

When a small proportion of nanotubes (e.g., 5-20 parts by weight) are mixed with a large proportion of fluorocarbon resin (e.g., 100 parts by weight) as taught by Ohata, the nanotubes become embedded within, and are fully coated by, the resin. *Id.* ¶105 (citing MRD-2009, 2 (“In a CNT–PVDF–NMP suspension, PVDF molecular chains would ***coat onto CNT surface due to the strong interaction between PVDF and CNTs.***”); LGES-1014, 3 (explaining that functionalized CNTs become “***completely covered*** with matrix” when mixed with resin); MRD-2024, 65:21-66:9 (admitting resin covers a “significant amount” of CNT surface)). Numerous objective references prove this point.

As one example, field emission scanning electron micrographs (FESEM) of a composite of 2% by weight functionalized multi-wall CNTs (“f-CNT”) to 98% by weight PVDF are depicted below in the excerpt of Figure 2(c)-(d):



Id. ¶106 (citing MRD-2010, 15). PVDF is a fluorocarbon resin used in the masterbatch of Ohata. *Id.* (citing LGES-1004 ¶[0022]). Figure 2(a) depicts the PVDF and Figure 2(b) depicts the f-CNTs. *Id.* ¶107 Figures 2(c) and (d) depict the functionalized CNT-PVDF composite, which shows the nanotubes embedded within the PVDF matrix. *Id.* (citing MRD-2010, 8-9). The dark circles in FIGS. 2(c) and (d) are voids in the PVDF matrix. *Id.* The CNT networking beneath the surface of the resin is not visible due to its opaque nature, but the CNTs closer to the surface are visible and clearly embedded within the PVDF matrix. *Id.* ¶¶108-109 (citing MRD-2010, 11-12 (“microspheres of polymer have been formed throughout the

composites and *carbon nanotubes are homogeneously dispersed within the polymer 3D scaffold.*”).

In another example, multi-wall CNTs were ultrasonically dispersed and then mixed with a solution of PVDF in dimethyl sulfoxide (a solvent) to obtain 3%, 5% and 9% by weight of CNTs in PVDF. MRD-2011, 2-3. Each weight percentage falls within the 5 to 20 parts by weight range of Ohata. MRD-2006 ¶110. The FESEM results are depicted below in Figure 1:

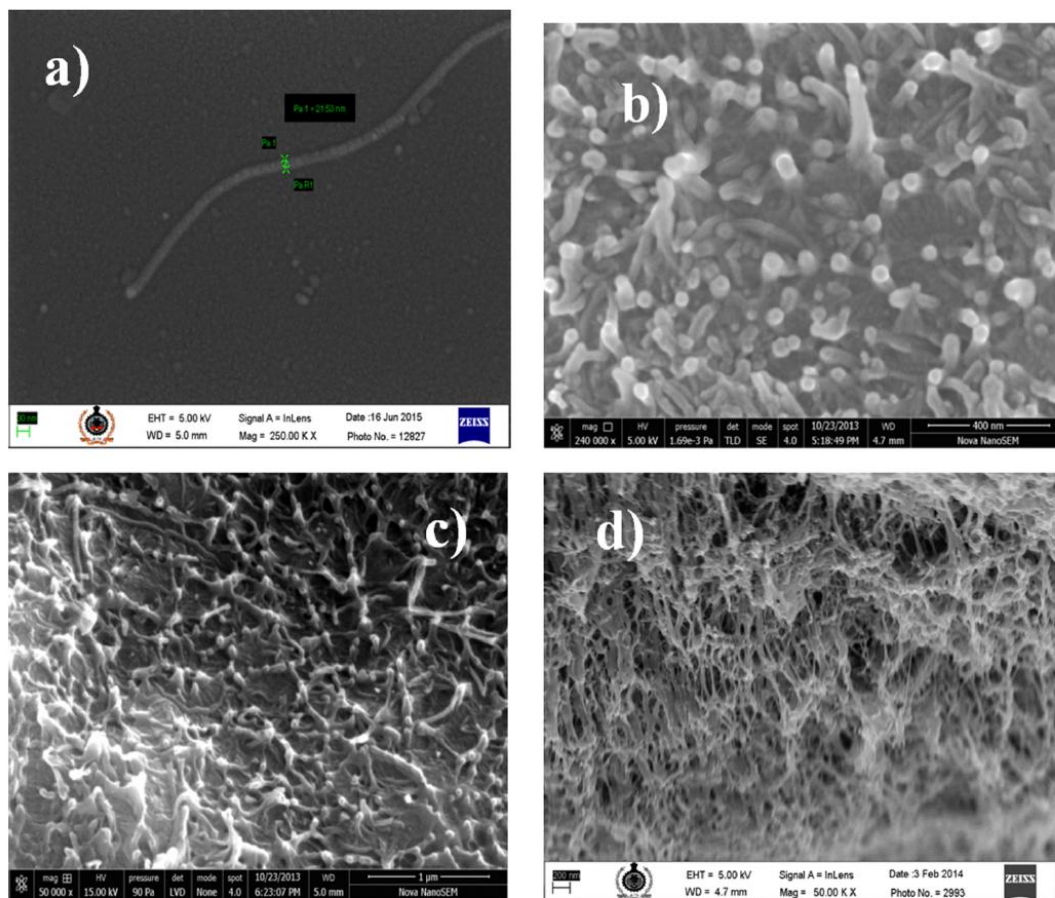
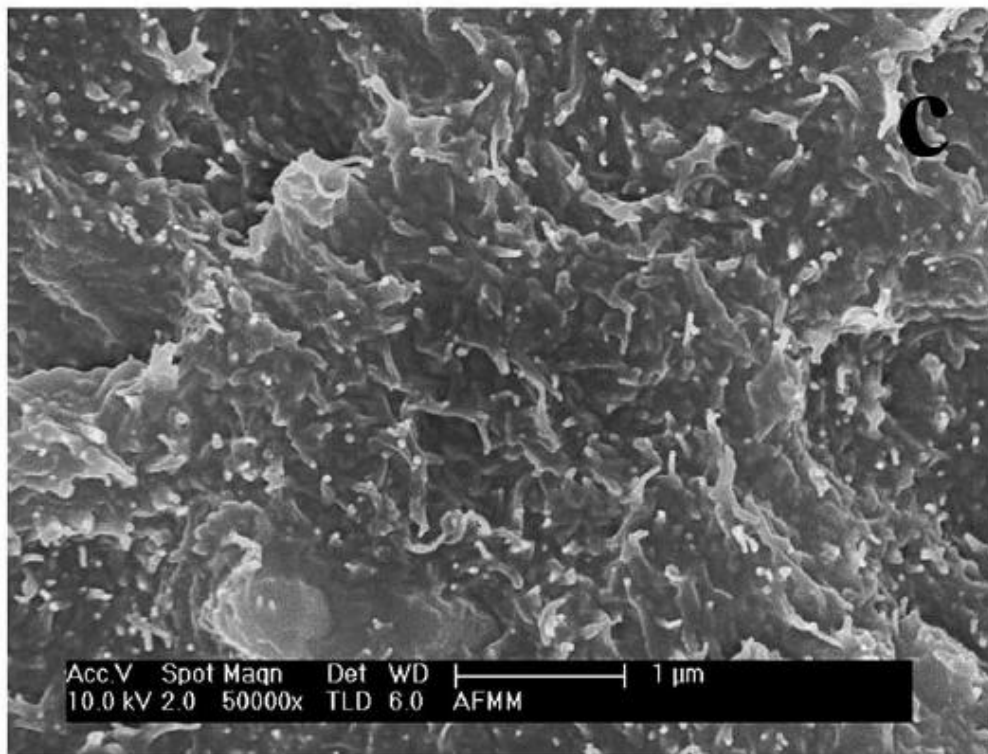


FIG. 1. FE-SEM images of MWCNT in the PVDF matrix. (a) shows a single MWCNT, and images of well dispersed MWCNTs for 3wt%, 5wt% and 9wt% samples in the PVDF matrix are shown in b), c) and d) respectively.

MRD-2011, 3. As shown in Figures 1(b)-(d), at all three weight percentages the CNTs are heavily embedded within the PVDF matrix—the CNTs are coated by PVDF. MRD-2006 ¶¶111-112 (citing MRD-2011, 3 (“Figure 1 shows the field-emission SEM micrographs of the MWCNTs *in PVDF matrix*.”)). In Figure 1(b) at 400 nm scale, the CNTs with a diameter of ~15 nm appear as thick “fingers” about 50 nm larger in diameter than the CNTs themselves, evidencing that they are heavily coated by PVDF. *Id.* ¶112. In Figure 1(c) at a 1 µm scale, the nanotubes also appear thick (about 100 nm in diameter), again evidencing the presence of PVDF covering the CNTs. *Id.* In Figure 1(d) at a 200 nm scale, there are visible CNTs that appear as if they are trapped in a “web,” which is the PVDF matrix. *Id.*

In another example, an SEM image depicts 3% by weight of multiwalled CNTs mixed with PVDF:



Id. ¶113 (citing MRD-2012, 6). The CNTs are embedded “in PVDF matrix,” which presents as a viscous substance *Id.* (quoting MRD-2012, 3; citing MRD-2013, 3, Figure 2 (showing how PVDF presents as blob-like domains of the matrix)).

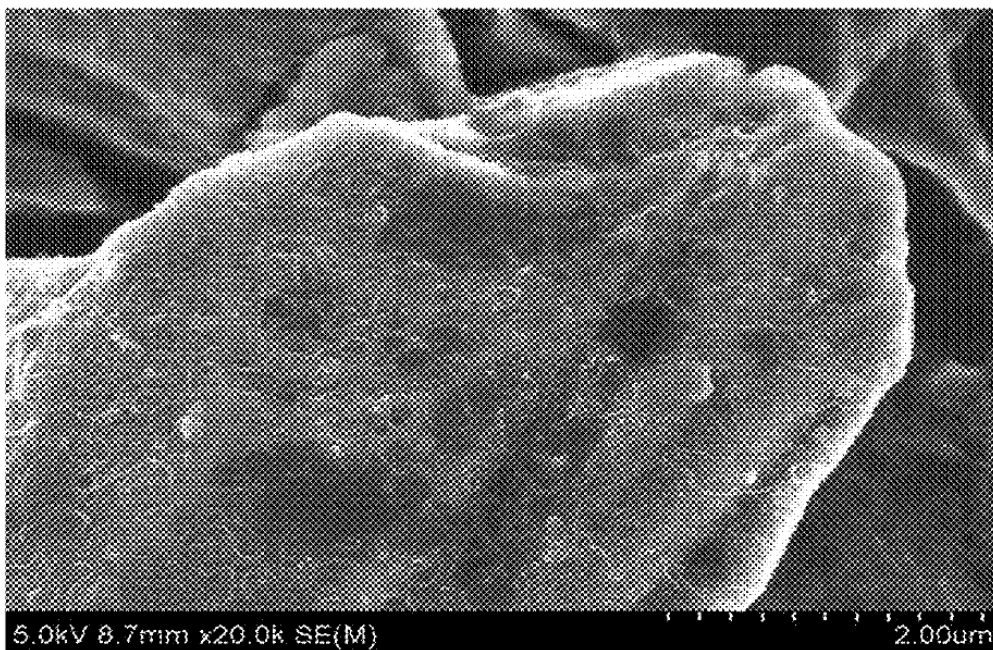
Each of these references demonstrates that the masterbatch of Ohata-Kavan would result in oxidized CNTs heavily coated with binder resin to form a viscous “glue” like material, similar to the glue of Figure 6 of Liu-009. *Id.* ¶114. Indeed, Liu-009 states that, when carbon black is mixed with PVDF prior to adding the active material, the PVDF will be “bonded to” the carbon black. *Id.* (citing MRD-2008, 7:55-62) (explaining that “the binder has previously and preferentially **bonded to the CB [i.e., carbon black]**”). A POSITA would understand that PVDF molecules

likewise bond to oxidized CNTs due to the dipole-dipole interactions between the highly polar fluorine atoms of the PVDF molecules and the presence of functional groups on the surface of the oxidized CNTs. *Id.* ¶1115. This interaction allows for significant interfacial adhesion between PVDF and oxidized CNTs. *Id.* In other words, the oxidized CNTs would not only be heavily embedded and coated with the PVDF matrix, but the PVDF coating would be more strongly bound to the oxidized CNTs due to these interactions. *Id.* (citing MRD-2009, 2 (“In a CNT–PVDF–NMP suspension, PVDF molecular chains would ***coat onto CNT surface due to the strong interaction between PVDF and CNTs.***”)). Importantly, Dr. Zhu testified that he was unaware of this important interaction between PVDF and oxidized CNTs. MRD-2024, 45:16-46:14.

Therefore, the proposed combination of Ohata-Kavan would result in a masterbatch comprising oxidized CNTs that are fully coated with the fluorocarbon resin. *Id.* ¶1116. This is the intentional design of Ohata, because the masterbatch acts as the binder but with embedded CNTs to improve binder conductivity. *Id.* Ohata *wants* its CNTs to be embedded within and coated by the resin particles, while the exterior of the binder remains exposed to the active material to glue the active materials together. *Id.*

As a comparison point, the SEM image below provides an example of CNTs in contact along the surface of an active material particle:

FIG. 4



Id. ¶117 (citing MRD-2028 ¶¶[0114]-[0115]). However, this example follows a process more similar to Kavan’s, where naked CNTs are mixed simultaneously with active material—not a “masterbatch” process that immerses the CNTs in resin before mixing the CNTs with the active material. *Id.* (citing MRD-2028 ¶[0108]). The result shown above is simply not possible in Ohata-Kavan due to its unique masterbatch process. *Id.*

The subsequent steps of Ohata-Kavan do not change the fact the CNTs are coated by resin. After the masterbatch is prepared, it is used to form the electrode material mixture paste. *Id.* ¶118 (citing LGES-1004 ¶[0005]). This involves using the masterbatch as the binder by mixing it with a “dispersion medium” (e.g., NMP)

and active material to form the electrode material mixture paste. *Id.* (citing LGES-1004 ¶¶[0023]-[0024], [0046]). For instance, in Example 1, Ohata discloses mixing 3.3 parts by weight of the masterbatch with 100 parts by weight of active material and 45 parts by weight of NMP. *Id.* (citing LGES-1004 ¶[0032]). NMP is a solvent that disperses the PVDF by dissolving it to break the matrix up into PVDF domains (or “islands”) so that the domains can be dispersed throughout the electrode material mixture, providing local glue-like bonds between adjacent active material particles. *Id.* In other words, smaller binder particles are dispersed throughout the electrode mixture, but the CNTs are still embedded within and coated by PVDF that is bonded to the CNTs. *Id.* ¶119. Indeed, the Ohata-Kavan masterbatch process does not teach or suggest filtering PVDF after creation of the electrode paste, which would be required to eliminate the PVDF domains. *Id.*; MRD-2024, 41:5-25. Thus, dispersing PVDF having embedded conductive agent (e.g., CNTs) using organic solvent (e.g., NMP) still leaves the conductive agent “coat[ed]” with PVDF. *Id.* (citing MRD-2015, 1:31-34 (“PVDF dissolved in the organic solvent **tends to coat particles** of the active material and the conductive agent, so that PVDF is not distributed effectively between these particles.”)).

Additional references further prove this point. FESEM images Figures 2 and 3 (reproduced below) show that even after PVDF and CNTs have been mixed with NMP, the CNTs are still heavily embedded within and coated by the PVDF:

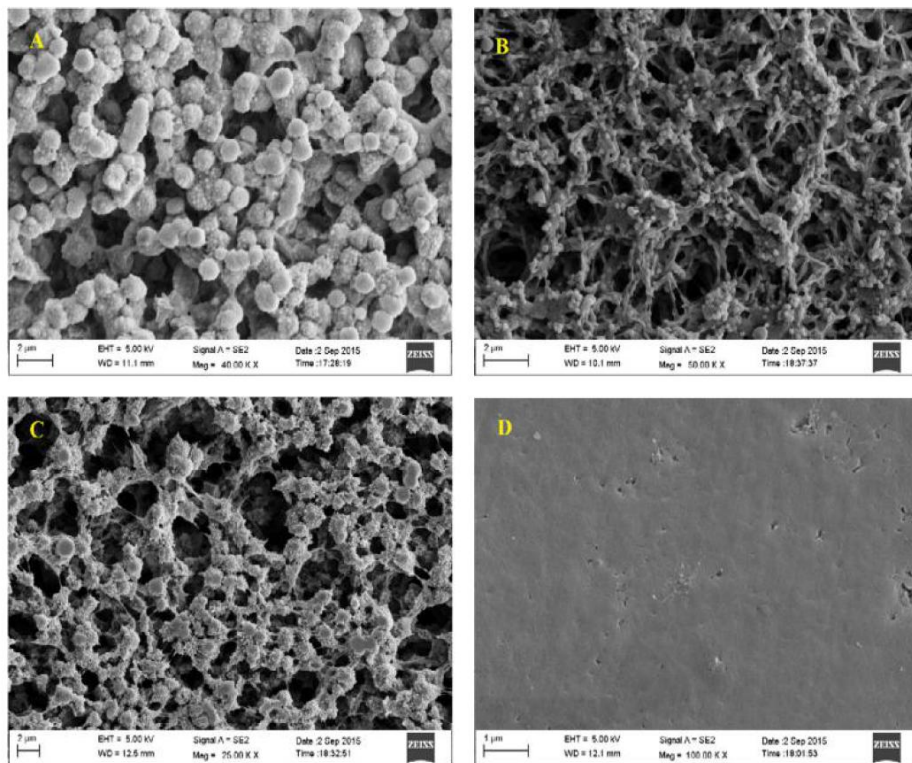


Fig. 2. (A–D): FESEM image of (A) PVDF, (B) PVDF with CNT, (C) PVDF with carbonic acid functionalised CNT and (D) PVDF with sulphonic acid functionalised CNT.

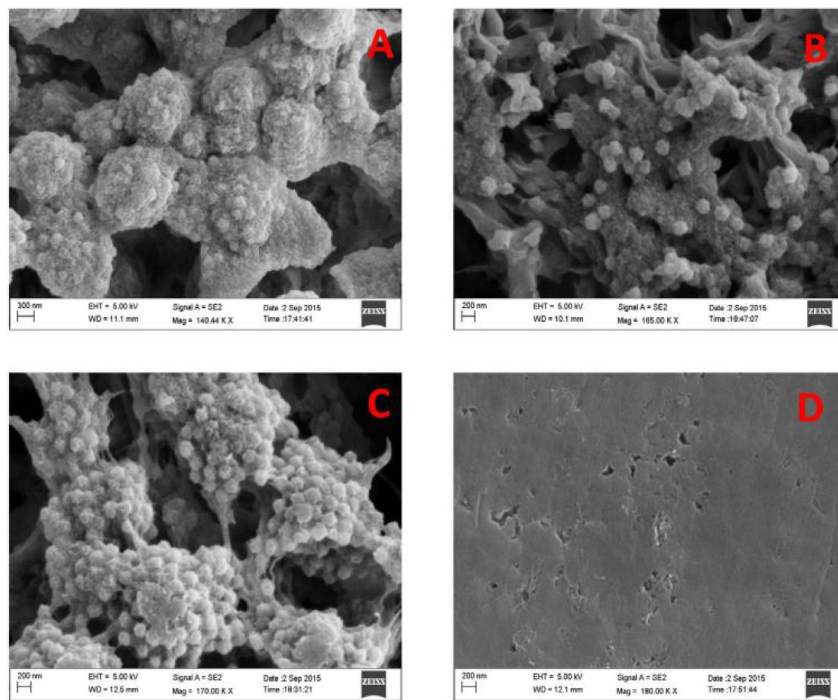


Fig. 3. (A–D) High Magnification FESEM image of (A) PVDF, (B) PVDF with CNT, (C) PVDF with carbonic acid functionalised CNT and (D) PVDF with sulphonic acid functionalised CNT.

Id. ¶120 (citing MRD-2014, 8). The “grainy” features in Figures 2(B), 2(C), 3(B) and 3(C) are the CNT-containing PVDF domains. *Id.* Additional, higher magnification FESEM images of Figure 3 show the PVDF matrix coating the CNTs more clearly. *Id.* Similarly, once the CNTs of the Ohata-Kavan masterbatch are blended with the resin, the entire surface of the CNTs becomes covered with resin, which is not removed by the solvent used during the electrode material mixture process. *Id.* ¶121.

An SEM image shown in Figure 2(f) below is of an electrode comprising CNTs (2% by weight), PVDF (3% by weight), and LiFePO₄ (95% by weight):

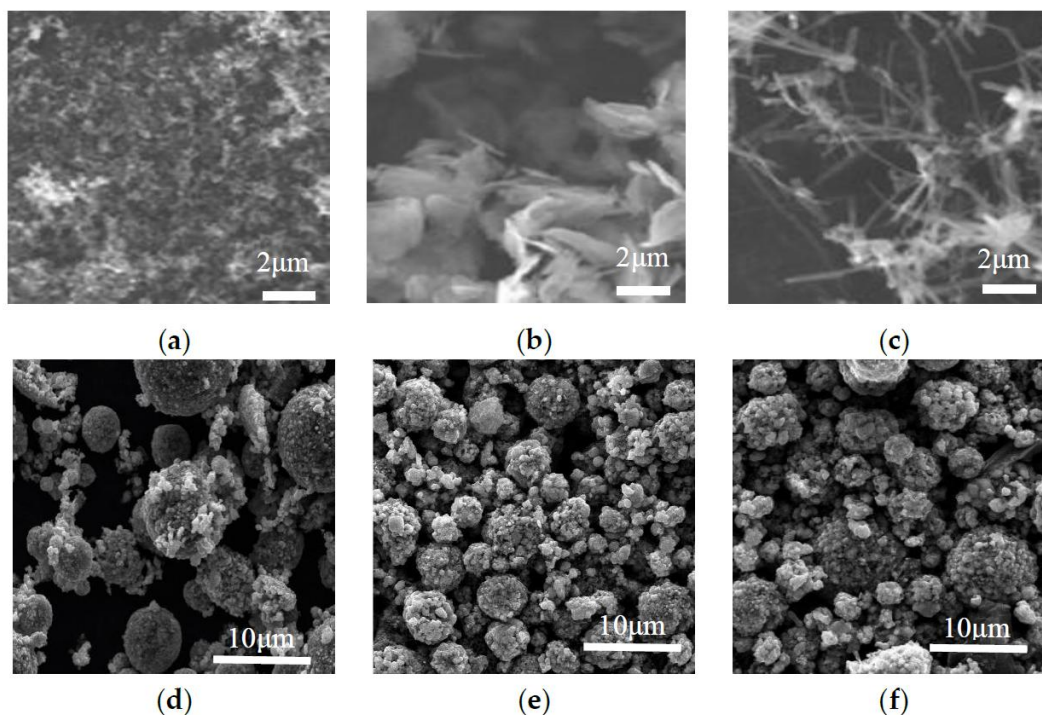


Figure 2. SEM of conductive agents and electrodes with different conductive materials: the surface morphologies of Super-P and KS-15 (a); the surface morphologies of graphene (b); the surface morphologies of carbon nanotube (c); the electrodes image of Super-P and KS-15 (d); the electrodes image of graphene (e); the electrodes image of carbon nanotubes (f).

Id. ¶122 (citing MRD-2016, 2, 4). Although this process does not follow the “masterbatch” process of Ohata, the results here demonstrate that mixing NMP solvent with PVDF resin does not eliminate the PVDF domains or coatings that exist. *Id.*

As another example, U.S. Patent Application Publication No. 2014/0319429 (“Nicolas-429”) specifically identifies Ohata and drawbacks of its masterbatch process. *Id.* ¶123 (citing MRD-2017 ¶¶[0009]-[0010]). Nicolas-429 proposed its own “masterbatch” process. In Example 3, the process uses “5% by weight of CNTs, 1% by weight of PVP, 0.8% by weight of PVDF and 93.2% by weight of NMP” to form a paste, which is then mixed with LiFePO₄. *Id.* (citing MRD-2017 ¶¶[0111]-[0118]). As shown below, domains of PVDF exist despite the use of a solvent (NMP) to disperse the PVDF:

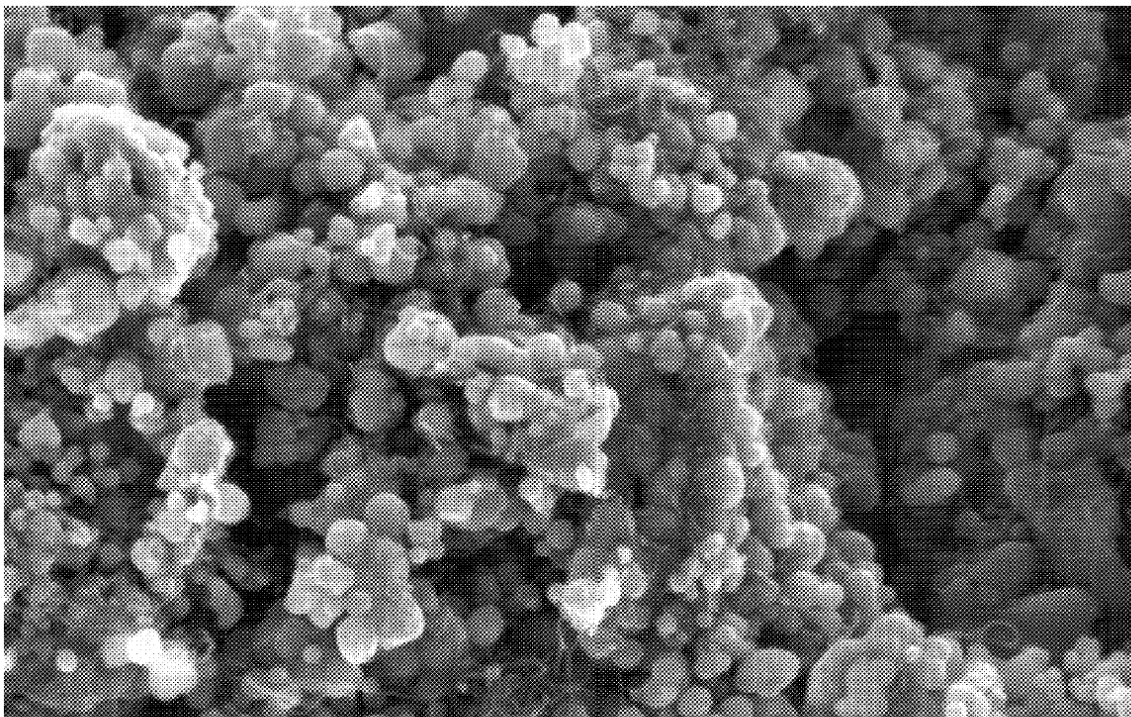


FIGURE 2

Id. Nicolas-429 states that Figure 2 shows “CNTs are well dispersed **around** the micrometric LiFePO_4/C particles.” MRD-2017 ¶[0123]. They are “around” the particles but not attached to the particles, because they are embedded within PVDF domains that prevents the active material from attaching to the surface of the CNTs. MRD-2006 ¶123.² A POSITA would expect the same result in Ohata-Kavan. *Id.*

Another reference, U.S. Patent Publication No. 2011/0256454 (“Nicolas-454”), also references Ohata’s masterbatch process. *Id.* ¶124 (citing MRD-2018

² Contrast this with LGES’s accused products, where discrete CNTs can very clearly be seen attached to the surface of the active material. *See e.g.*, LGES-1033, 32, 35.

¶¶[0010]-[0011]). In FIGS. 2A and 2B, Nicolas-454 provides SEM images of its own masterbatch (comprising CNTs and PVDF) mixed with NMP and an active material (LiFePO_4):

FIG. 2A

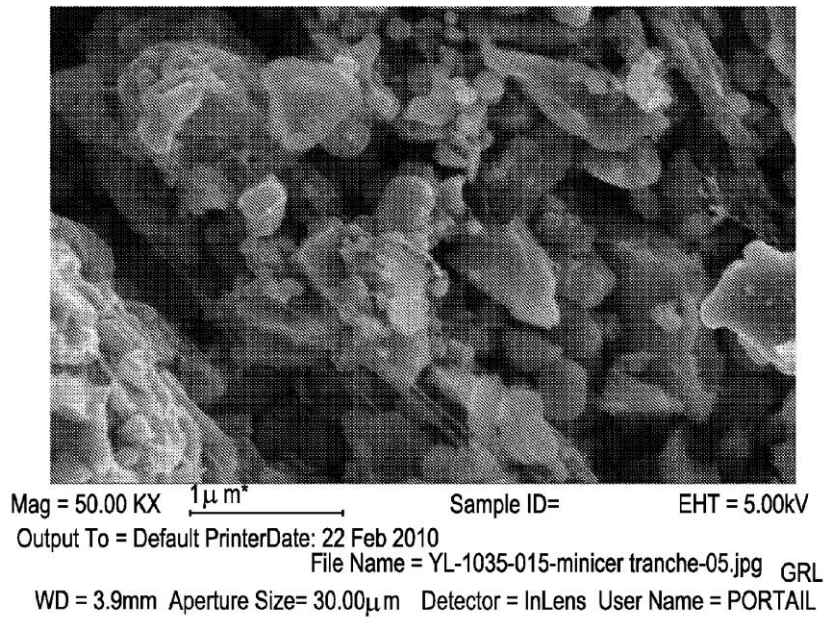
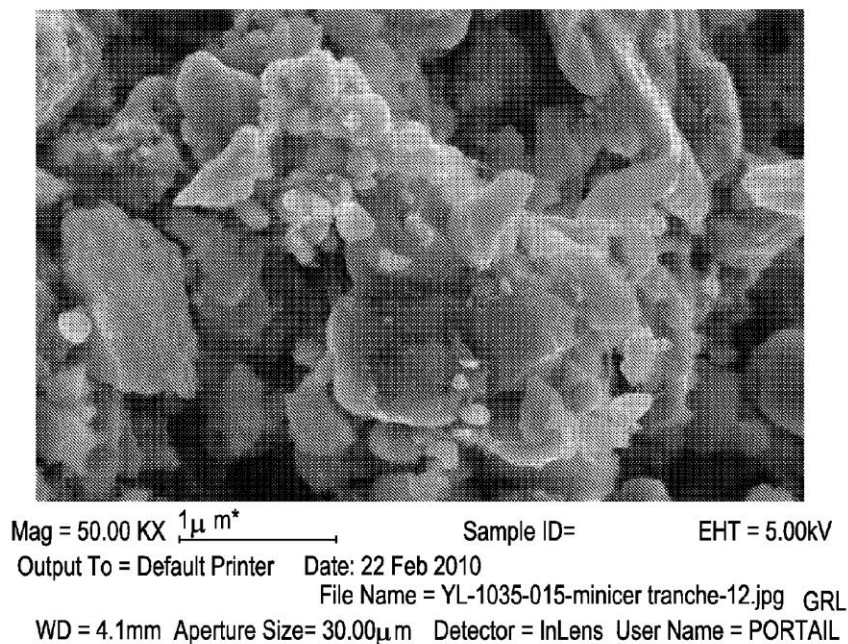


FIG. 2B



Id. ¶124 (citing MRD-2018, ¶¶[0121]-[0131]). The CNTs are fully embedded within the PVDF domains. *Id.*

Finally, the SEM image below shows “cathode particles with adhering PVDF/carbon black clusters” after NMP mixing:

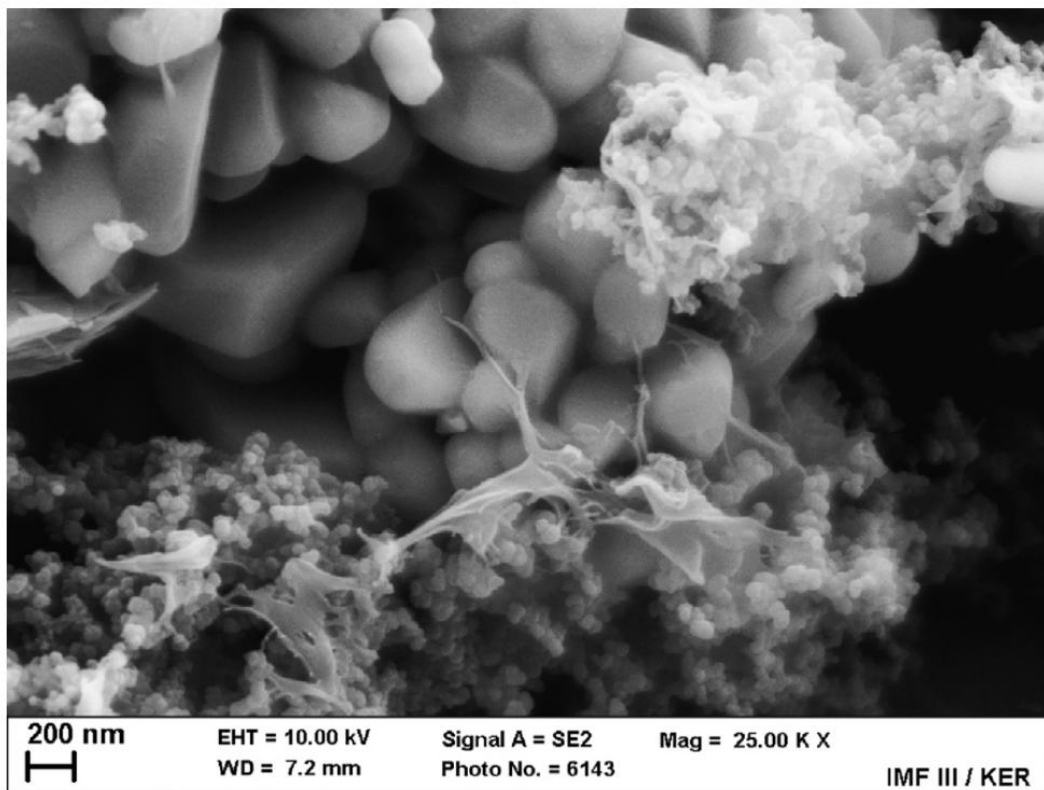


Fig. 13. SEM micrograph of a NMC cathode particles with adhering PVDF/carbon black clusters.

Id. ¶125 (citing MRD-2020, 7). The carbon black clusters entrained in the PVDF domains, which present as web-like or cloudy structures that the carbon black particles are embedded in. *Id.* The article teaches that mixing the carbon black with the binder first results in a “gel formation” and “**PVDF polymer layer**” that “**prevents direct contact** of particle surfaces.” *Id.* (citing MRD-2020, 6-7).

The foregoing evidence demonstrates that oxidized CNTs made pursuant to the masterbatch process of Ohata-Kavan would be fully embedded within and coated by the resin matrix, preventing the active material from attaching to the surface of

the CNTs. *Id.* ¶126. Instead, the active material would essentially be glued to the surface ***of the resin layer*** separating the active material from the surface of the CNTs. *Id.* The resin layers would exist at the molecular layer of the CNTs, meaning that it is impossible for the active material to attach to the surface of the CNTs. *Id.* Petitioner overlooks this critical fact in its obviousness analysis, incorrectly assuming that the sole reason for the “masterbatch” process of Ohata-Kavan is to create discrete CNTs. *Id.* ¶127. However, unlike the ’909 Patent and Kavan, which expose naked oxidized CNTs to the active material during mixing, Ohata-Kavan covers the CNTs with resin and prevents the claimed attachment from occurring. *Id.* Indeed, when asked whether immersing oxidized CNTs in resin would prevent attachment, Dr. Zhu tellingly gave a lengthy non-response. MRD-2024, 36:8-37:25.³

3. Petitioner fails to demonstrate a motivation to combine to obtain “oxidation levels from 1% to 15%” based on Kavan.

A POSITA would have had no motivation to oxidize the CNTs of Ohata pursuant to Kavan, because he or she would have readily understood that the

³ Apparently recognizing that he overlooked the unique masterbatch process of Ohata-Kavan, Dr. Zhu offered the implausible testimony that the order of mixing materials for an electrode is irrelevant. MRD-2024, 50:7-51:4. But anyone that has ever baked—never mind created complex lithium battery compositions—knows that the order of mixing is often critical. MRD-2006, ¶[0127], n.6

masterbatch process of Ohata-Kavan would mitigate the benefits described by Kavan. MRD-2006 ¶129. The functional groups associated with the oxidation would be completely covered in resin, preventing the ion active material from “anchoring” to the surface of the CNTs. *Supra* V.A.2. A POSITA would have found it illogical to oxidize Ohata’s CNTs based on Kavan, given that the masterbatch process would destroy all oxidation benefits described by Kavan. MRD-2006 ¶129.

Oxidizing CNTs also adversely affects their desirable intrinsic properties, further discouraging a POSITA from oxidizing per Kavan. *Id.* ¶130. It was known that “while a greater degree of functionalization may improve the dispersibility of the CNTs, such improvement *may come at a decrease in intrinsic properties of the pristine CNTs.*” *Id.* (citing LGES-1021 ¶[0024]). This includes shortening the CNTs, reducing electrical conductivity, and even potentially causing the CNTs to split apart. *Id.* (citing LGES-1009, 1-2; MRD-2024, 19:13-17, 22:1-24:3). Although a POSITA may have determined, as Kavan did, that the benefits of “anchoring” provided by oxidation offset these drawbacks, those benefits simply **do not exist** in Ohata-Kavan due to the masterbatch process. *Id.*

Petitioner’s “reasons for the combination” fail because they ignore the effects of the masterbatch process. *Id.* ¶131. The “first” reason is that when a phosphate olive is used as the active material, “electrochemical performance of an electrode is improved by oxidized nanotubes.” Pet., 13. This reason is premised on the active

material *being able to “anchor” to the functional groups* of the oxidized CNTs. MRD-2006 ¶132.

In Kavan, this anchoring occurs because the *naked* oxidized CNTs are *mixed directly* with the active material in water. *Id.* ¶133 (citing LGES-1005, 2). Likewise, the '924 Patent teaches mixing naked oxidized CNTs with the active material to facilitate attachment. *Id.* (citing LGES-1001, 2:9-21). In contrast to both Kavan and the '924 Patent, in Ohata-Kavan the CNTs are *first* covered in resin during the masterbatch process, preventing this anchoring from occurring. *Id.* Consequently, the first reason does not support a motivation to combine.

The “second” reason is that “a POSITA would have been motivated to use oxidized nanotubes in furtherance of Ohata’s goal to have well-dispersed nanotubes in the composite.” Pet., 13. As with the first reason, this reason is fundamentally undermined by the masterbatch process. MRD-2006 ¶134. The improved dispersion described in Kavan is due to the functional groups interacting with water. *Id.* Specifically, the functional groups added via oxidation are polar, hydrophilic functional groups on the surface of the CNTs, which enhances the CNTs’ interaction with water, helping to reduce aggregation and promote dispersion. *Id.* (citing MRD-2024, 27:17-28:5). In Ohata-Kavan, the naked oxidized CNTs are not exposed to water, but instead are first covered in resin. *Id.* Because Kavan only teaches that naked oxidized CNTs mixed with water can help improve dispersion, Kavan does

not support the assertion that oxidizing the resin-covered CNTs of Ohata-Kavan would improve dispersibility. *Id.* And even if oxidation *generally* would have been understood to help disperse CNTs in the resin of Ohata-Kavan, Petitioner still fails to show obviousness, because the only basis for alleged obviousness of the claimed **oxidation level** is Kavan—which relies on a fundamentally different interaction between water and the functional groups (not the resin and the functional groups). *Id.* ¶135.

The “second” reason also lacks merit, because Petitioner contends that Ohata alone *already* achieves uniformly dispersed CNTs. Pet., 22 (arguing in Ohata “a conductive material is **uniformly predispersed** in a binder”) (quoting LGES-1004 ¶[0002])). Because Petitioner alleges that Ohata already achieves uniform dispersal without oxidation, there would have been no motivation to oxidize to improve dispersion. MRD-2006 ¶136. This is particularly so given that it was well-known that oxidation would adversely affect the intrinsic properties of CNTs. *Id.*

The “third” reason is that oxidation can help purify the CNTs. Pet., 14. But nothing in Ohata or Kavan teaches or suggests that the CNTs have impurities. MRD-2006 ¶137. To the contrary, Kavan teaches that it uses “purified” CNTs, which refers to CNTs lacking impurities. *Id.* (citing LGES-1005, 2 (“For oxidative functionalization, 1g of *purified* nanotubes was mixed....”). Thus, there is no evidence to support this “purification” motivation.

Petitioner further contends that “a POSITA would have been motivated to use oxidized nanotubes in the Ohata-Kavan paste.” Pet., 15. But the issue is not simply whether a POSITA would have been motivated “to use oxidized nanotubes,” but whether there was a motivation to use oxidized CNTs ***at the claimed level of 1% to 15%***. Petitioner cannot rely on motivations to oxidize *generally*. The only basis for the assertion that ***the claimed range*** was obvious is based on Kavan’s oxidation level—but that oxidation level is premised on the goal of “anchoring” to provide the described benefits. Because the Ohata-Kavan masterbatch process precludes these benefits from coming to fruition, Petitioner fails to provide any motivation for oxidizing at claimed level. Further, given the well-known disadvantages of oxidizing CNTs, and that a POSITA understood that the “anchoring” benefits of Kavan would not be achieved in Ohata-Kavan, a POSITA would have further lacked motivation to oxidize at Kavan’s levels. MRD-2006 ¶138.

The “fourth” reason is essentially a rehash of the first three, couched in terms of applying a known technique to a known structure ready for improvement to yield predictable results. Pet., 14-15. This reason is thus inadequate for at least the reasons discussed above. Indeed, the so-called “predictable results based on functionalization of the carbon nanotubes” simply ignores the effects of the Ohata-Kavan masterbatch process, which fundamentally undermines the motivations. *See DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 567 F.3d 1314, 1326 (Fed. Cir. 2009) (“[T]he

‘predictable result’ discussed in [*KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398 (2007)] refers not only to the expectation that prior art elements are capable of being physically combined, but also that the combination **would have worked for its intended purpose.**”). There is simply no evidence that oxidizing at the levels taught by Kavan would have worked for its intended “anchoring” purpose in Ohata-Kavan when accounting for the effects of the masterbatch process. MRD-2006 ¶240.

In addition to the lack of motivation, Ohata teaches away from the combination. “A reference may be said to teach away when a person of ordinary skill, ..., would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant.” *In re Gurley*, 27 F.3d 551, 553 (Fed. Cir. 1994). “[A] reference will teach away if it suggests that the line of development flowing from the reference’s disclosure is unlikely to be productive of the result sought.” *Id.*; see also *Par Pharm., Inc. v. Twi Pharms., Inc.*, 773 F.3d 1186, 1198 (Fed. Cir. 2014). Upon reading Ohata, a POSITA “would be led in a direction divergent from the path that was taken by the applicant.” *In re Gurley*, 27 F.3d at 553.

First, Ohata teaches that “[a]lthough it is possible to add a resin during the step of preparing an electrode material mixture paste, the addition of the carbon nanotubes **is difficult, taking the dispersibility of the carbon nanotubes in the resin into consideration.**” LGES, 1004 ¶[0021]. Thus, Ohata teaches away from exposing

the naked CNTs to the active material, which is how Kavan “anchors” the active material to the oxidized CNTs. MRD-2006 ¶¶140-141 (citing LGES-1005, 2).

Second, a POSITA would be discouraged from oxidizing Ohata’s CNTs pursuant to Kavan, because it would have been understood that the benefits of “anchoring” taught by Kavan would not be achieved because the masterbatch process covers the CNTs in resin. *Id.* ¶142. This is particularly true given that oxidizing the CNTs per Kavan would come at the cost of damaging the intrinsic properties while providing none of the benefits taught by Kavan. *Id.*

4. Petitioner fails to demonstrate a reasonable expectation of success.

The reasonable expectation of success requirement “refers to the likelihood of success in combining reference to meet the limitations ***of the claimed invention.***” *Intelligent Bio-Systems, Inc. v. Illumina Cambridge, Ltd.*, 821 F.3d 1359, 1367 (Fed. Cir. 2016). A POSITA would have had no reasonable expectation of success in combining Ohata-Kavan such that the ion active material is “attached to th[e] surface” of the oxidized CNTs as claimed. MRD-2006 ¶143. Petitioner was required to demonstrate a reasonable expectation of success *in the Petition*, but instead simply ignored the fact that Ohata-Kavan embeds the oxidized CNTs in resin before mixing with the active material. Indeed, implicit in all of Petitioner’s “reasons” for a reasonable expectation of success is the incorrect assumption that

Ohata-Kavan exposes the CNTs to the active material like Kavan. *Id.* A POSITA would have had no expectation of success when considering that the oxidized CNTs would be covered in resin, preventing the attachment described by Kavan. *Id.*

5. Petitioner fails to demonstrate that Ohata-Kavan teaches or renders obvious “discrete carbon nanotubes.”

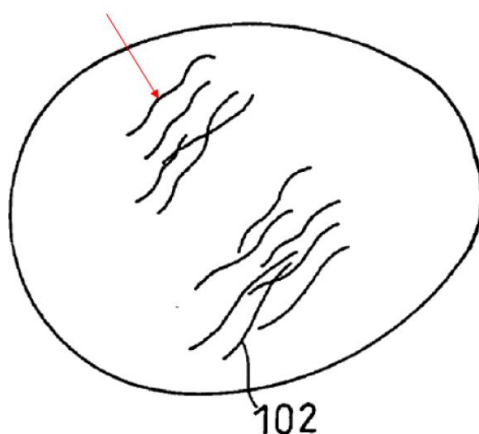
Petitioner proposes that “discrete” CNTs means “generally individually distinct nanotubes” (Pet., 21-22) that are “fully isolated” or “separated” from one another. MRD-2023 ¶[0083]; MRD-2024, 11:4-8 (testifying that CNTs are “discrete” “because” they are “fully isolated” from one another), 12:17-13:22 (testifying that “discrete” CNTs are “separated from each other”). This is consistent with the plain and ordinary meaning of “discrete,” as evidenced by its usage in the specification and the common meaning of “discrete.” MRD-2006 ¶146 (citing LGES-1001, 1:45-49 (“discrete, i.e., individual, uniformly dispersed tubes”), 3:52-54 (“discrete” CNTs are “separated to give individual tubes”); MRD-2007, 8 (defining “discrete” as “separate and distinct; not attached to others; unrelated”)).

Petitioner alleges that Ohata-Kavan achieves “discrete” CNTs. Pet., 21. Petitioner relies on Ohata’s statement that its CNTs “are tangled and twisted with one another” but then are “*unraveled and straightened*” by blending them with a resin as part of the masterbatch process. *Id.*, 22 (emphasis in original) (citing LGES-1004 ¶[0015]). Petitioner argues “that a POSITA would have found it obvious that

at least some of these ‘unraveled and straightened carbon nanotubes’ are discrete because they are generally ‘*dispersed*’ as *individual nanotubes* in the resin.” *Id.*

Petitioner annotates Figure 1(b) of Ohata (reproduced below) to identify CNTs that it contends are “discrete.”

“discrete carbon nanotubes”



Petitioner fails to carry its burden of demonstrating that Ohata-Kavan results in “discrete” CNTs. As an initial matter, Petitioner’s reliance on cartoon Figure 1 of Ohata is misplaced. Ohata itself calls Figure 1 a “schematic” diagram, which conceptually illustrates the **concept** of disentangling CNTs by shearing. MRD-2006 ¶¶147-148 (citing LGES-1004 ¶¶[0012]-[0013]). A POSITA would not rely on such a schematic as a real-world representation of actual masterbatch results. *Id.* ¶148. It would instead be understood for what it is—an illustration intended to conceptually depict the well-known concept of CNT disentanglement via shear forces. *Id.*

The actual results of Ohata’s masterbatch process would be reflected by SEM

or TEM images, similar to how both the '924 Patent and Kavan evidence their findings. *Id.* ¶149. Indeed, Figure 1(b) depicts the CNTs as somehow being oriented in nearly the exact same direction and generally parallel to one another, rather than at random orientations, which is implausible. *Id.* ¶¶149-150. A POSITA would know that Figure 1 is an unrealistic, conceptual drawing. *Id.* For example, an SEM image from Gan shows CNTs mixed in a resin to form a conductive polymer composite:

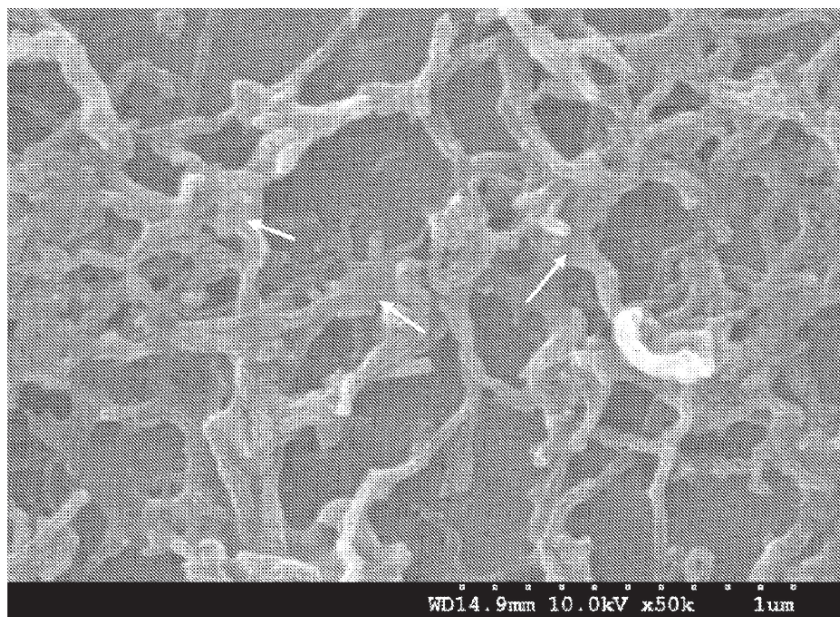


FIG.5

Id. (citing LGES-1021 ¶¶[0014], [0041]). Although Gan does not purport to achieve discrete CNTs, this image shows how the CNTs of Ohata's masterbatch would be randomly oriented, facilitating the formation of a continuous network of CNTs embedded within the binder that glues the active material together. *Id.*

Even if the Board accepts Figure 1 of Ohata as representative of how the CNTs would present in the masterbatch, Petitioner fails to demonstrate that they would remain discrete after *being further mixed* with the active material to create the *electrode material mixture paste*. A POSITA would understand that the goal of Ohata is to create a continuous network of CNTs embedded in the binder, providing improved electrical conductivity between active material particles. *Id.* ¶151 (citing LGES-1004 ¶[0004] (“it is an object of the present invention to provide an electrode superior in **conductivity** with a small amount of conductive material”); LGES-1004 ¶¶[0018]-[0020] (explaining that when the CNT’s diameter is too large, the CNT’s length is too short, or the aspect ratio is too small, “excellent **conductive paths** may not be formed in some electrodes.”)). This was a well-known and common goal for electrodes at the time of the invention. *Id.* (citing LGES-1007 ¶[0005]; LGES-1021 ¶[0041]).

Consistent with this goal, Ohata teaches a prior method of pre-dispersing carbon black (i.e., a “conducting material”) in resin binder as part of a “masterbatch” process. *Id.* ¶152 (citing LGES-1004 ¶[0002]). The linked “chain” of carbon black forms a continuous “conductive path” in the binder, which increases electrical conductivity. *Id.* (citing LGES-1004 ¶[0003]). Ohata teaches, however, that the shearing force associated with mixing the masterbatch breaks the conductive path, and therefore, “does not yield an electrode superior in conductivity.” *Id.*

Ohata's proposed solution to this problem is to use CNTs to form the continuous network rather than carbon black. *Id.* (citing LGES-1004 ¶[0015]). Nothing suggests that Ohata was seeking to achieve discrete CNTs as part of its electrode material mixture paste, as this would create gaps in the conductive network, contrary to Ohata's express goal of creating an "electrode **superior in conductivity**" and conventional wisdom at the time. *Id.*

The only reason Ohata seeks to "unravel" and "straighten" the CNTs is so that they can be better dispersed to form a continuous network better distributed throughout the binder. *Id.* ¶153. This is because it was well-known that heavier entanglement of CNTs "is undesirable because it results in formation of voids and aggregates in the composition which adversely effects the **electrical conductivity properties** of the composite...." *Id.* (quoting LGES-1021 ¶[0027]; citing LGES-1007 ¶[0073] (explaining CNT agglomeration makes it "difficult to form an effective conductive network")). Just as a heavily wound spiderweb is more difficult to spread apart, heavily entangled CNTs make it more difficult to disperse a CNT network. *Id.* Ohata seeks better dispersion of its CNTs so that it can provide a **continuous network** of CNTs throughout the entire binder, not to achieve discrete CNTs attached to the surface of active material. *Id.*

Even if the *masterbatch* of Ohata-Kavan would comprise discrete CNTs, Petitioner fails to demonstrate that the same can be said of the *electrode material*

mixture paste, which is created by mixing the masterbatch with the active material and a dispersion medium. *Id.* ¶154 (citing LGES-1004 ¶[0023]). As evidenced by Figure 5 of Gan below, the random orientation of CNTs in a fluid facilitates the CNTs connecting to one another to forming a continuous conductive network. *Id.* (citing LGES-1021 ¶¶[0014], [0041]).

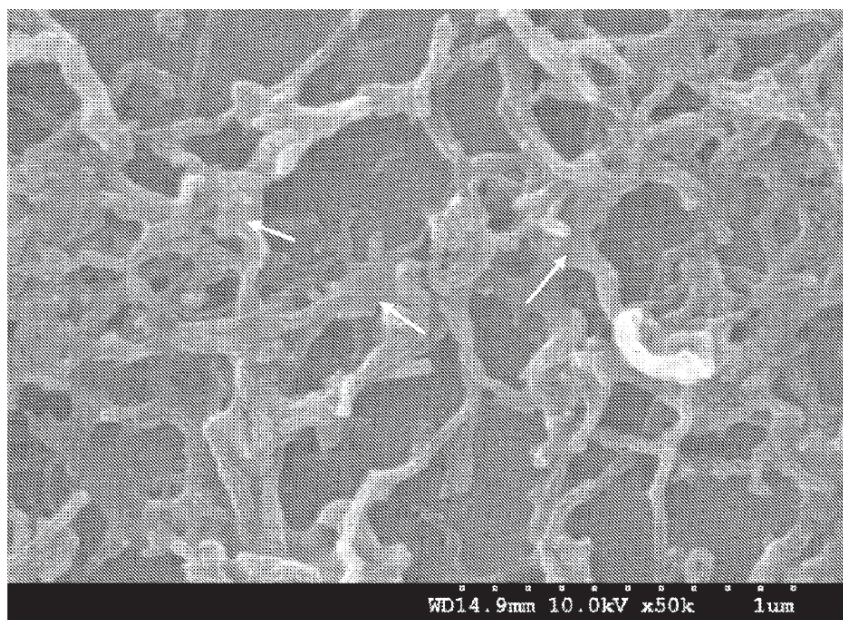


FIG.5

The formation of a continuous conductive network is only further facilitated when *oxidized* CNTs are mixed in a polymer (e.g., the resin of Ohata-Kavan), because the functionalization of the CNTs “[r]educes contact resistance between CNTs incorporated into the conductive polymer material by ***drawing the CNTs close together***” and “[p]rovides a ***conductive bridge between*** CNTs.” *Id.* ¶155 (quoting

LGES-1021 ¶¶[0018]-[0021]); MRD-2026, 50:17-53:6 (agreeing). The formation of a continuous network of CNTs is a primary goal of Ohata—it *wants* the CNTs to be interconnected to form a continuous network to improve conductivity. *Id.* And the only reason Ohata teaches “unraveling” and “straightening” the CNTs is to make it easier to disperse them through the binder so that a continuous network is achieved throughout the entire binder—avoiding network “voids.” *Id.* In view of the above, Petitioner fails to demonstrate by a preponderance of the evidence that the *electrode material mixture paste* of Ohata-Kavan would comprise discrete CNTs. *Id.*

Apparently recognizing that its invalidity theory based on Figure 1 of Ohata is tenuous, Petitioner also “alternatively/additionally” argues that “a POSITA would have understood or found obvious that the nanotubes in the combination composition are **discrete** because, at least in some instances, oxidation of nanotubes can help promote non-agglomeration of nanotubes.” Pet., 23 (emphasis in original). According to Petitioner and its expert, oxidizing CNTs necessarily results in “discrete” CNTs. *Id.*, 23-24. Petitioner fails to provide sufficient evidence to prove this assertion.

While oxidation of CNTs can improve their dispersibility, CNTs that are dispersed (even uniformly dispersed) are not necessarily “discrete.” MRD-2006 ¶¶156-157. For example, CNTs forming a continuous network (i.e., the clear goal of Ohata) throughout an entire composition are “dispersed” throughout the composition

even though the CNTs are interconnected (i.e., **not** “discrete”). *Id.* In fact, Gan teaches that functionalized CNTs within a polymer will be drawn closer together and provide a conductive bridge between CNTs, facilitating the formation of a continuous network. *Id.* (citing LGES-1021 ¶¶[0018]-[0021]). Dr. Zhu agrees with Gan and admits that both of these effects result in CNTs ***in contact with one another*** to form a ***continuous*** conductive network. MRD-2026, 50:17-53:6. It is unsurprising then that Petitioner provides no objective evidence to support its assertion that merely oxidizing CNTs *necessarily* achieves discreteness. Kavan itself depicts CNTs that have been oxidized, yet Petitioner does not contend they are discrete. LGES-1005, 3 (Fig. 2, top right). Consequently, Petitioner’s attempt to rely on oxidation alone to demonstrate Ohata-Kavan would achieve “discrete” CNTs should be rejected. MRD-2006 ¶157.

VI. Grounds 2A and 2B: Cheng-Gan Does Not Render Any Claim Unpatentable

A. Overview of Prior Art

1. Cheng

Cheng attempts to “solv[e] the problem in the prior art in which carbon nanotubes are distributed only on the surface of the electrode [active] material,” which prevents “a ***continuously connected three-dimensional electrically***

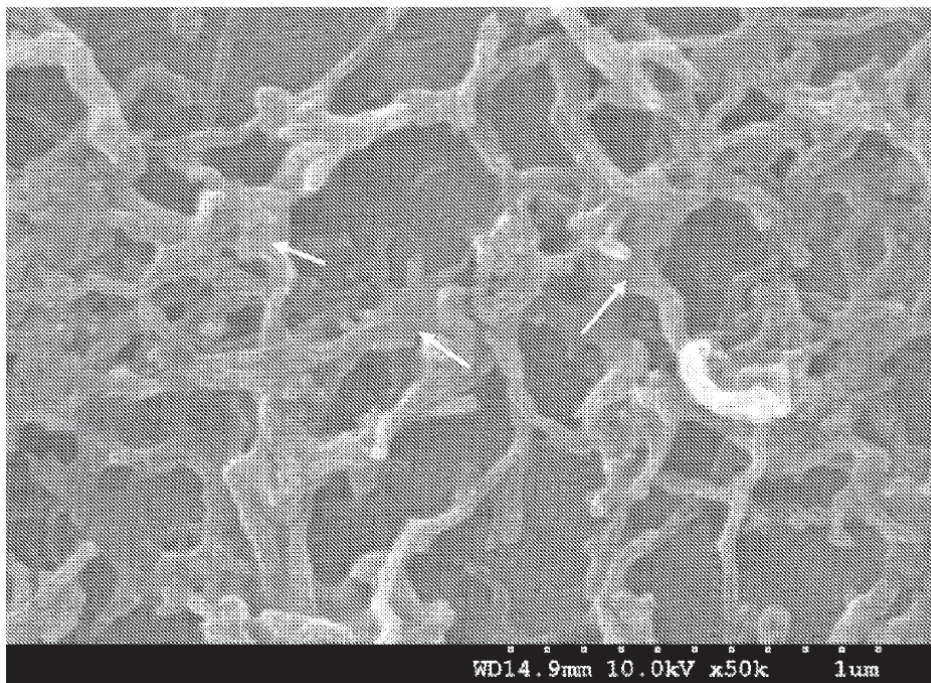
conductive network structure both in the interior and on the surface of the [active] material” from forming. MRD-2006 ¶¶158-160 (quoting LGES-1007 ¶[0010]).

Cheng’s method generally involves three steps. *Id.* First, making a CNT dispersion by taking unoxidized CNTs, acetylene black, and a dispersing agent and ultrasonically dispersing them in water or an organic solvent to obtain a mixture. LGES-1007 ¶[0013]. Second, making a precursor powder dispersion by mixing a lithium source, an iron source, a phosphate salt, and an organic carbon source into the mixture from the first step, followed by adding a mixing and milling medium and perform mixing ball-milling and drying. *Id.* ¶¶[0014]-[0015]. Third, performing an in situ solid phase reaction, specifically, a carbon thermal reduction, by taking the precursor powder dispersion from the second step and **calcining it to temperatures of “600 °C to 850 °C in an inert protective atmosphere for 4 to 48 hours, pulverizing the burned materials, and then sieving.”** *Id.* ¶[0019]. The high temperature calcining is required to: (1) convert the carbon source into carbon to act as a binder; and (2) form the lithium iron phosphate (i.e., active material) from the lithium, iron, and phosphate sources. MRD-2006 ¶161; MRD-2026, 38:18-39:14.

2. Gan

Gan is directed toward “composites of carbon nanotubes and conductive polymer materials.” MRD-2006 ¶162 (quoting LGES-1021 ¶[0002]). In reference to Figure 5 (reproduced below), Gan seeks to achieve a “percolated network” of CNTs

and conductive polymer that “form a continuous conductive path extending through the composite.” LGES-1021 ¶[0041]. Gan states that the presence of such a continuous conductive path is believed to be the reason the polymer has increased electrical conductivity. *Id.*



Gan teaches that “it is preferred that the CNTs are functionalized,” which can provide the following benefits:

1. Improves the solubility and *dispersibility* of the CNTs in water and conductive polymer materials into which the CNTs are to be mixed.
2. Reduces contact resistance between CNTs incorporated into the conductive polymer materials *by drawing the CNTs closer together*; and
3. Provides *a conductive bridge* between CNTs to reduce the electrical contact resistance therebetween.

Id. ¶¶[0018]-[0021]. Gan teaches that functionalization can adversely affect the desirable intrinsic properties of the CNTs, and thus, the “amount of functionalized CNTs utilized will be limited to those amounts below which agglomeration of the CNTs within the polymer material matrix is avoided.” *Id.* ¶¶[0024]-[0027]. Agglomeration is undesirable “because it results in formation of voids and aggregates” that “adversely affects the electrical conductivity properties of the composite as well as the physical properties of the composite.” *Id.* ¶[0027]. A POSITA would understand that these “voids” are gaps in the continuous conductive network of CNTs that lead to reduced electrical conductivity. MRD-2006 ¶163-165.

B. Independent Claim 1

1. Petitioner fails to show that Cheng-Gan satisfies the 1% to 15% oxidation requirement.

Petitioner argues that a POSITA would have been motivated to functionalize the CNTs of Cheng to “about 2.5 to 10 wt%” per Gan. Pet., 41. However, Petitioner overlooks that Cheng-Gan performs a carbon thermal reduction that ***calcines the CNTs at 600°C to 850°C for 4 to 48 hours***. LGES-1007 ¶[0019]. Petitioner does not propose modifying Cheng-Gan to eliminate this step, which is a mandatory step in all embodiments of Cheng to (1) convert the carbon source into carbon and (2) form the lithium iron phosphate. MRD-2006 ¶¶168-170 (citing MRD-2038, 1; MRD-2034, 1); MRD-2026, 38:18-39:5.

The calcining would remove essentially all of the oxidized groups from the CNT surfaces, bringing the oxidation level below 1 wt%. *Id.* ¶171. For instance, a reference relied on by Petitioner teaches that at much lower temperatures of 150 °C to 350 °C, “**decarboxylation** of the carboxylic groups present on the MWCNT walls” occurs. LGES-1009, 7. “Thermal degradation in the range between the 350 °C and 500 °C may be explained by the **elimination of hydroxyl functionalities, attached to the MWCNT walls.**” *Id.* A POSITA would expect that at Cheng-Gan’s much higher minimum calcination temperature of 600 °C, essentially all of the functional groups of Chen-Gang would be removed, particularly given the 4-hour minimum calcining time. MRD-2006 ¶171.

Numerous other references demonstrate this. One shows that “[t]he removal of the hydroxyl functionalities attached to the walls of carbon nanotubes is known to occur in the 350–550°C interval.” *Id.* ¶172 (quoting MRD-2029, 4). Another shows that as the temperature applied to oxidized CNTs increase from about 100 °C to about 325 °C, functional groups are removed. *Id.* ¶173 (discussing MRD-2030, 3). Yet another evidences that as the temperature applied to oxidized CNTs increases beyond 200 °C, the weight loss due to the removal of the oxidized groups continuously increases. *Id.* ¶¶174-177 (discussing MRD-2031, 2-3). Applying a temperature of 600 °C to oxidized CNTs for 30 minutes results in less than 2% oxidation. *Id.* ¶178 (discussing MRD-2032,7). However, that is only about 12% of the 240-minute

minimum calcining time of Cheng. *Id.* Cheng's minimum calcination temperature of 600 °C for a 4-hour period would result in an oxidation level of less than 0.75 at.% (1 wt.%) of the CNTs. *Id.*

Petitioner's expert admits that functional groups would be removed due to the high calcination temperatures of Cheng-Gan. MRD-2026, 42:15-20, 43:3-6. He also admits that the that the level of removal is affected by temperature and time. *Id.*, 44:1-14. Recognizing the problem that Cheng-Gan's calcining presents, he alleged for the first time that the oxidation removal would be limited because the CNTs are mixed "with other things" that react. *Id.*, 41:5-42:14. Of course, there is no evidence of this in the Petition. Regardless, the reason Cheng-Gan requires calcination at high temperatures for four hours is because those reactions *take a long period of time*. MRD-2006 ¶¶179-180. Given the high temperature and long period of calcination, a POSITA would expect essentially all of the functional groups to be removed before these reactions begin. *Id.*

Moreover, if the functional groups were truly protected because they are *part* of the reactions (as Dr. Zhu alleges), removal of oxidation would ***be accelerated***. *Id.* ¶181(explaining that it was known that the thermal tolerance of functional groups degrades in reactive environments). The functional groups would also adversely interfere with the formation of the lithium iron phosphate under Dr. Zhu's theory. *Id.* ¶¶ 182-184 (citing MRD-2042, 1).

Tellingly, none of the references relied on by Petitioner involve oxidized CNTs heated to anywhere near the temperature or times required by Cheng. Indeed, Gan teaches that its oxidized CNT mixtures are only heated to 100 °C. LGES-1021 ¶¶[0037]-[0038]. Likewise, Kavan teaches drying its electrode material mixture comprising oxidized CNTs at 100 °C. LGES-1005, 2. The highest temperature disclosed in the '924 Patent is 185 °C. LGES-1001, 5:44-45, 5:19-20, 6:24-25. These temperatures are well below the known temperatures for significant thermal removal of functional groups—whereas the minimum temperature of 600 °C for 4+ hours taught by Cheng far exceeds it. MRD-2006 ¶185.

Petitioner carries the burden of demonstrating that Cheng-Gan would result in CNTs with oxidation levels from 1 wt% and 15 wt%. However, Petitioner fails to explain how this limitation is met when accounting for the calcination step. Petitioner references the calcination step three times and includes it in the Cheng-Gan combination, but provides no evidence that the CNTs oxidized would have oxidation levels within the claimed range after calcination. Pet., 52, 56, 57. Instead, Petitioner incorrectly assumes that the CNTs as oxidized pursuant to Gan, would retain the same oxidation levels taught by Gan alone. Because they clearly would not, Petitioner fails to carry its burden of demonstrating that the oxidation levels in Cheng-Gan are from 1% to 15% by weight of the CNT. MRD-2006 ¶186.

Recognizing this, Dr. Zhu repeatedly contended that the calcining is merely “optional” and that Cheng-Gan *could have* used a lower temperature. MRD-2026, 40:11-41:4, 28:28-29:4, 31:1-12, 39:6-9. He is plainly mistaken. As he admits, Cheng *requires* calcination to form the lithium iron phosphate (active material) and to convert the carbon source into carbon. *Id.*, 31:1-6, 38:18-39:13; MRD-2006 ¶187. Moreover, Petitioner did not propose Cheng-Gan without its calcination step, and Petitioner cannot raise new obviousness theories. *Henny Penny Corp. v. Frymaster LLC*, 938 F.3d 1324, 1330-31 (Fed. Cir. 2019).

2. Petitioner fails to demonstrate a motivation to oxidate at levels from 1% to 15%.

A POSITA had no motivation to oxidize the CNTs of Cheng, because it was readily understood that the calcining would remove functional groups associated with the oxidized CNTs, resulting in oxidation levels below the minimums of both Gan (2.5 wt.%) and the claims (1 wt.%). *Supra* Section VI.B.1. Indeed, it is illogical to oxidize CNTs when the required calcining would remove essentially all of those functional groups. MRD-2006 ¶189. Moreover, Gan teaches that oxidation levels below 2.5 wt.% and above 10 wt.% are not “suitable” because the oxidation would negatively affect the “intrinsic properties of the pristine CNTs” without providing an adequate benefit. *Id.* ¶190 (citing LGES-1021 ¶[0024]). Gan thus teaches away from

higher oxidation levels (e.g., 25 wt.%) that might, hypothetically, result in higher oxidation levels *after* calcination. *Id.*

A POSITA would be strongly discouraged from relying on CNTs oxidized per Gan, because a POSITA would readily understand that Cheng's calcining step would destroy the key benefits provided by the added functional groups and oxidizing CNTs comes at the cost of damaging the intrinsic properties of the CNTs. MRD-2006 ¶¶191-192 (citing LGES-1021 ¶[0024]).

Petitioner's specific motivations to oxidize at Gan's disclosed levels also fail. The first "motivation" is "to achieve a better constructed electrically conductive network of nanotubes." Pet., 42. The second "motivation" offered is "to enhance dispersion of carbon nanotubes." *Id.*, 43-44. Petitioner acknowledges that both motivations are premised on the benefits provided by the functional groups associated with oxidation. *Id.* 42-44. However, those functional groups would be essentially all removed during calcining, undermining both motivations. MRD-2006 ¶193.

The third "motivation" offered is that Gan's oxidation levels "remains within a safe threshold that preserves 'the desirable intrinsic properties of the CNTs.'" Pet., 44. However, the fact that oxidizing CNTs would not be detrimental is ***not a motivation to oxidize in the first place.*** MRD-2006 ¶194.

The fourth “motivation” is that oxidized CNTs were well-known and commercially available. Pet., 45. The mere fact that oxidized CNTs were used in the industry and available for purchase says nothing about whether there is a *reason* to use them in the hypothetical Cheng-Gan combination. MRD-2006 ¶195. *PersonalWeb Techs., LLC v. Apple, Inc.*, 848 F.3d 987, 994 (Fed. Cir. 2017).

The fifth “motivation” is that it was known that oxidation creates “anchors” and improve “colloidal stability of CNTs.” Pet., 46. Again, however, the alleged benefits here are tied to the functional groups associated with the oxidation. MRD-2006 ¶196. Cheng-Gan’s calcination would remove these “anchors,” eliminating the purported benefits. *Id.*

The sixth “motivation” is essentially a rehash of the first five, couched in terms of applying a known technique to a known device ready for improvement to yield predictable results. Pet., 47. It is inadequate for at least the reasons discussed above. Indeed, the so-called “predictable results based on functionalization of the carbon nanotubes” simply ignores the required calcination of Cheng-Gan, which fundamentally undermines the motivations. MRD-2006 ¶197; *see Depuy Spine, Inc.*, 567 F.3d at 1326. There is no evidence that there was an expectation that Cheng-Gan would have worked for its intended purpose when accounting for the calcination step—a key step Petitioner failed to consider.

Petitioner also asserts that “a POSITA would have been motivated to use [1] oxidized carbon nanotubes.” Pet., 42. However, the issue is not whether a POSITA would have simply been motivated “to use oxidized carbon nanotubes,” but whether a POSITA would have been motivated to use oxidized carbon nanotubes *at the oxidation levels claimed*. The only basis for Petitioner’s position that the ***claimed oxidation range*** was obvious is Gan’s disclosure of oxidation levels of about 2.5 to about 10 wt%. Pet., 42. Because calcining would result in CNTs oxidized below the 2.5 wt% minimum of Gan, there would have been no motivation to combine. MRD-2006 ¶198.

3. Petitioner fails to demonstrate a reasonable expectation of success in light of the calcining step.

A POSITA would have had no reasonable expectation of success in combining Cheng-Gan such that the CNTs maintain (1) Gan’s required minimum level of 2.5 wt% or (2) the minimum level of 1 wt% required by the claims. MRD-2006 ¶200. Petitioner was required to demonstrate a reasonable expectation of success *in the Petition*, but instead simply ignored the calcination step of Cheng-Gan. Indeed, implicit in all of Petitioner’s “reasons” for a reasonable expectation of success is the incorrect assumption that the oxidation levels in Cheng-Gan would “fall within the range disclosed in Gan (2.5–10 wt%).” Pet., 48-50. However, a POSITA would have

had a reasonable expectation of success of achieving oxidation above either level *when considering the effects of calcination*. *Id.* ¶¶199-200.

4. Petitioner fails to demonstrate that Cheng-Gan achieves “discrete” CNTs.

Contrary to Petitioner’s assertions, Cheng-Gan does not yield discrete CNTs. Cheng and Gan are both trying to form a *continuous* or *percolated* conductive network of fibrous CNTs. MRD-2006 ¶201 (citing LGES-1007 ¶[0005]; LGES-1021 ¶[0041]). While they seek uniform distribution of CNTs, the objective is for the CNTs to be interconnected (i.e., not “discrete”) to provide improved conductivity. *Id.* Dr. Zhu agrees. MRD-2026, 12:23-13:1, 18:12-19:4, 54:16-55:23. Petitioner’s assertions are premised on (1) incorrectly equating the terms “uniformly dispersed” with “discrete,” and (2) incorrectly equating the steps of Cheng-Gan to the fundamentally different steps of the ’924 Patent. Pet., 51-55.

a. Cheng-Gan actively seeks to avoid discrete CNTs

Cheng’s design goal is to form a “*continuously connected* three-dimensional electrically conductive network” of CNTs and active material. MRD-2006 ¶202; *Supra* Section VI.A.1. The aggregation of CNTs severely hinders this objective, because it can cause discontinuities (voids) in a network of CNTs. MRD-2006 ¶203. To address the adverse effects of CNT agglomeration, Cheng seeks a “[u]niform *dispersion* of carbon nanotubes.” *Id.* ¶204 (quoting LGES-1007 ¶[0007]). Cheng is

not seeking to eliminate the interconnectivity of the CNTs—it instead wants to make the CNTs easier to disperse so that a more comprehensive **continuous** network of CNTs is formed throughout the composite. *Id.*

Gan is likewise attempting to form a “continuous” network of CNTs throughout its composite and recognizes that generally “the amount of functionalized CNTs utilized will be limited to those amounts *below which agglomeration* of the CNTs within the polymer material matrix is avoided.” *Id.* ¶205 (quoting LGES-1021 ¶[0027]). Gan teaches that it wants to avoid aggregates of CNTs, which results in voids where there are inadequate interconnected CNTs to form the conductive network. *Id.* (citing LGES-1021 ¶[0027]).

Figure 5 of Gan (below) is an SEM image of non-functionalized CNTs, a conductive polymer (“PEDOT”) and a non-conductive binder (“PSS”), which shows that the CNTs form a “**continuous** conductive path through the composite.” LGES-1021 ¶[0041]. The white arrows “identify locations where the PEDOT:PSS effectively wraps around and binds with the MWNTs to form a **percolated network**.” Gan explains that this continuous conductive path is believed to be the reason the composite has increased electrical conductivity. MRD-2006 ¶¶206-207.

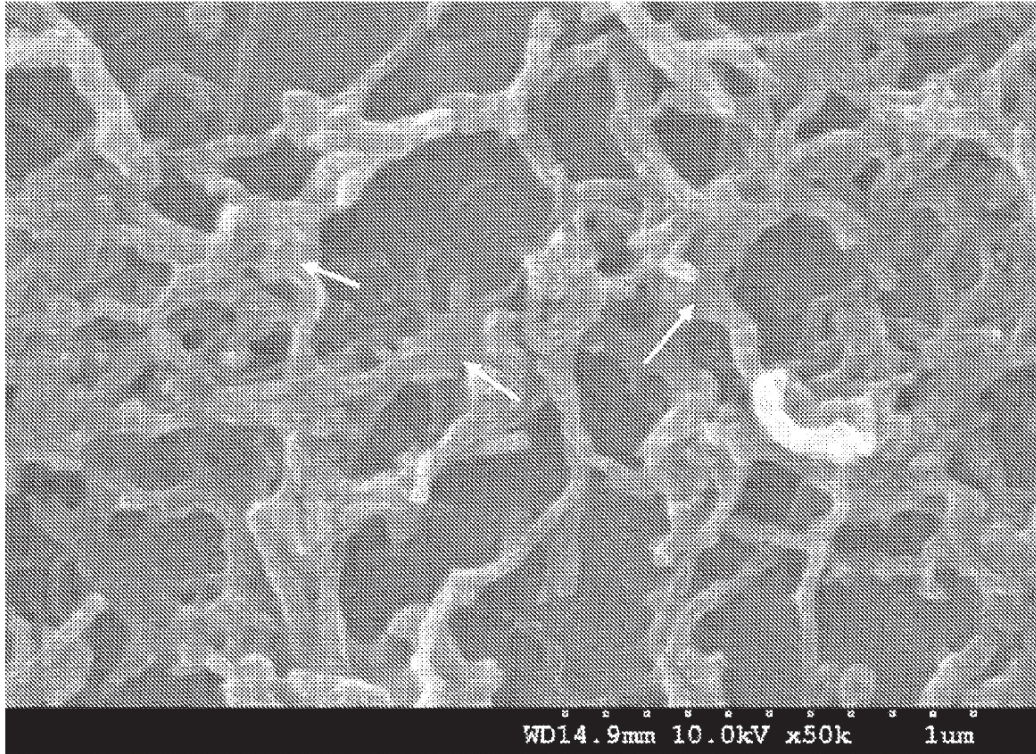


FIG.5

Can also teaches that functionalization of CNTs achieves at least three objectives: (1) improved solubility and dispersibility, (2) reduced contact resistance between CNTs that draws them closer together, and (3) providing a conductive bridge between CNTs. LGES-1021 ¶¶[0019]-[0021]. A POSITA would understand that these objectives are directed toward ***maintaining an interconnected network*** of CNTs by bringing the CNTs closer together and avoiding aggregation that results in network voids. MRD-2006 ¶¶208-209.

In summary, Cheng and Gan both seek a “continuous” or “percolated” network of CNTs, whereby the CNTs are non-agglomerated and better dispersed throughout a composition. *Id.* ¶210. Neither reference teaches or suggests that the CNTs are discrete or that having discrete CNTs is a goal. *Id.* Indeed, having discrete CNTs in Cheng and Gan would run contrary to the purpose of both references, which is to maintain a *continuous* or *percolated* network of CNTs throughout. *Id.* There is no indication that either Cheng or Gan recognized that having discrete CNTs attached to the surface of the active material provides any benefit, such as retardation of active material cracking. *Id.*

b. Petitioner fails to show “discrete” CNTs.

Despite Cheng and Gan both seeking a continuous network of CNTs, Petitioner argues that Cheng-Gan would result in “discrete” CNTs. Pet., 51-55. However, Petitioner’s arguments are premised on incorrectly equating “discrete” CNTs with “uniformly dispersed” or “non-agglomerated” CNTs. Pet., 51-55. CNTs can be “non-agglomerated” and “uniformly dispersed” without being “discrete.” MRD-2006 ¶211. For example, a continuous network of CNTs can be uniformly distributed throughout an electrode composition, in which case the CNTs may be “non-agglomerated” and “uniformly dispersed.” *Id.* However, those CNTs are not “discrete” because they are continuously connected (i.e., each CNT is connected to another CNT). *Id.* This is precisely the type of CNT network that Cheng and Gan

seek to achieve. *Id.* Neither Cheng nor Gan teach or suggest that they are seeking to achieve “discrete” CNTs, and all of Petitioner’s “discrete” arguments are premised on the falsely equating “uniformly dispersed” and “non-agglomerated” CNTs to “discrete” CNTs. *Id.*

i. “First” argument

Petitioner’s first argument relies on Cheng’s teachings, arguing that Cheng achieves “fully dispersed” and “uniformly dispersed” CNTs to “form a continuously connected three-dimensional electrically conductive network structure both in the interior and on the surface of the material.” Pet. 51-52. However, “uniformly dispersed” and “fully dispersed” CNTs do not mean “discrete.” MRD-2006 ¶212. Indeed, independent claim 5 further limits the “discrete” CNTs of claim 1 to being “uniformly dispersible” and the specification uses “uniform dispersion” and “discrete” as separate characterizations of CNTs, proving they are not the same. LGES-1001, 2:29.

Cheng does not teach or suggest discrete CNTs anywhere. MRD-2006 ¶213. The words “discrete,” “individual,” or “distinct” do not appear in Cheng. *Id.* This is because Cheng seeks a more comprehensive interconnected network of CNTs throughout its composition, while avoiding aggregation that results in voids. *Id.* The inclusion of discrete CNTs would result in undesirable voids in the “continuous network,” contrary to Cheng’s stated purpose. *Id.* Indeed, the very portion of Cheng

quoted by Petitioner teaches that Cheng seeks a “***continuously*** connected” network, which is inconsistent with having discrete CNTs. MRD-2006 ¶214 (citing Pet., 37 (quoting LGES-1021 ¶[0010])).

ii. “Second” argument

Petitioner’s second argument is that Cheng teaches that its material results in a “**non-aggregated** and **uniform dispersion** of nanotubes.” Pet., 52 (emphasis in original). As an initial matter, Cheng never uses any form of the word “aggregate.” Even if it did, neither “non-aggregated” nor “uniform dispersion” mean “discrete.” MRD-2006 ¶215. Petitioner relies on quoted terms from Cheng—“effective conductive ***network***” and “uniformly distributed ***network structure***.” Pet., 53 (quoting LGES-1007 ¶¶[0021], [0023])). However, each quote supports that Cheng desires a *network* of connected CNTs, because the goal of Cheng is to have a uniformly distributed ***continuous*** network of CNTs spread throughout its composite. MRD-2006 ¶215 (citing LGES-1007 ¶¶[0021], [0023])).

iii. “Third” argument

Petitioner argues “third” that Cheng teaches that the diameter and length of the CNTs “contribute to **lesser aggregation** and **better dispersion** of carbon nanotubes, thereby contributing to the **uniform dispersion** and **non-aggregated state** of **nanotubes**.” Pet., 53 (emphasis in original). To support this, Petitioner cites Cheng’s teaching that “the carbon nanotubes are **less entangled** with each other and

are **more easily dispersed.**” *Id.* (quoting LGES-1007 ¶[0021]) (emphasis in original). Yet, none of the bolded terms mean “discrete.” MRD-2006 ¶216.

The cited portions of Cheng merely teach that it was known that the diameter and length of CNTs can affect **dispersibility**. *Id.* ¶217. They do not demonstrate that Cheng achieved “discrete” CNTs, which would undermine his stated goal of achieving a “continuously connected” network of CNTs. *Id.* In fact, Cheng does not teach that the CNTs are “**not** entangled,” but merely “less entangled with each other and are more easily dispersed.” *Id.* (citing LGES-1007 ¶[0021]). A POSITA would understand that “less entangled” means that there is still a degree of entanglement, but by being “less entangled” the CNTs can be more easily dispersed to help ensure that the continuous network of CNTs covers more volume of the composite material. *Id.*

iv. “Fourth” argument

The “fourth” argument is the vague assertion that since Example 2 of the ’924 Patent (hereafter, “Example 2”) describes three sequential steps, and since Cheng-Gan allegedly performs “similar steps” in the same order, a POSITA would have understood Cheng-Gan to “likely yield similar dispersion results” as Example 2. Pet., 53-54. Specifically, Petitioner alleges that “Example 2 of the ’924 Patent describes sequential steps of [1] forming oxidized carbon nanotube / solvent mixture based on ultrasonic dispersion, [2] mixing the mixture with lithium source, iron source and

phosphate source with mixing medium (e.g., deionized water), and [3] heat treatment” (hereinafter, “Steps [1], [2], and [3]”). Pet., 53-54. Petitioner contends that Cheng discloses three similar steps. *Id.*

In granting institution, the Board noted that Patent Owner did “not address Petitioner’s assertion” regarding these allegedly similar steps and results, and determined the argument was “sufficiently persuasive for purposes of institution.” Institution Decision (“DI”), Paper 9, 30. Patent Owner now disproves this assertion.

Although the steps may appear similar in the abstract, the specific materials used and processes performed are materially and meaningfully different. MRD-2006 ¶¶218-219. The results from each respective process to likewise be materially different, particularly the dispersion results. *Id.*

Step [0] cutting and selection steps

The specification teaches “the process of making discrete carbon nanotubes,” involves cutting CNTs into segments, dissolving the residual catalyst, and properly selecting the CNT feedstock, including selecting evenly spaced catalyst sites. LGES-1001, 4:4-21. Neither Cheng nor Gan discloses a similar pre-processing step to “help with exfoliation” and achieve discrete CNTs. MRD-2006 ¶220. This distinction alone renders Petitioner’s comparison deficient.

Step [1] forming oxidized carbon nanotube / solvent mixture based on ultrasonic dispersion

In Step [1] of Example 2, 0.2 g of multi-wall CNTs with aspect ratio of about 60 are oxidized to about 8 wt.% and added to 23.5 g of diethylene glycol (a solvent) and sonicated for 15 minutes. LGES-1001, 5:36-39.

In Step [1] of Cheng-Gan, 10 g of [oxidized] CNTs with a length of 10-15 μm and a tube diameter of 50-150 nm and 6 g of **polyvinylpyrrolidone (PVP)** as a dispersing agent are added to 500 ml of deionized water. LGES-1007 ¶[0040]. After ultrasonic dispersion, 20 g of **acetylene black** is further added, followed by further ultrasonic or high-speed stirring and mixing. *Id.* ¶[0040].

Each step uses different materials and processes steps. MRD-2006 ¶221-223.

First, Example 2 starts with CNTs that have an aspect ratio of about 60 (LGES-1001, 5:36-38), not an aspect ratio ranging from 67-300. *Id.* ¶224 (citing Pet. 60).

Second, Cheng-Gan uses PVP as a dispersing agent for the CNTs. *Id.* ¶225 (citing LGES-1007 ¶[0040]). PVP is a water-soluble, nonionic polymer. *Id.* In contrast, Example 2 does not use any dispersing agent or any water-soluble nonionic polymer—it uses diethylene glycol solvent. *Id.* (citing LGES-1001, 5:38).

Third, the PVP in Cheng-Gan is calculated to have a ratio of the number of Li^+ ions (in 1000 g LiH_2PO_4) to the number of H_2O molecules (2 kg of water) of 8.67%. *Id.* ¶226 (citing LGES-1007 ¶[0041]). In contrast, Example 2 is calculated to

have a ratio of the number of Li^+ ions (in 0.65 g of lithium acetate) to the number of H_2O molecules (4.2 ml of water) of 4.23%. *Id.* (citing LGES-1001, 5:42-44). The higher Li^+ ion content of Cheng-Gan increases the viscosity, making it ***more difficult to disperse the CNTs.*** *Id.*

Fourth, Cheng-Gan uses **acetylene black**. *Id.* ¶227 (citing LGES-1007 ¶[0013]). In Example 2, neither acetylene black nor a similar substance is used. *Id.* (citing LGES-1001, 5:36-53). Importantly, Cheng teaches that acetylene black and CNTs can “agglomerate,” making it “difficult to form an effective conductive network.” *Id.* (quoting LGES-1007 ¶[0073]). Dr. Zhu agreed. MRD-2026, 23:5-9. This fact fundamentally distinguishes these methods, as Cheng-Gan would be expected to have increased agglomeration. *Id.*

Step [2] mixing the mixture with lithium source, iron source and phosphate source with mixing medium

In Step [2] of Example 2, 1.16 g of iron acetate (iron source) dissolved in 4 ml of deionized water is added to the mixture of Step [1], and then the mixture is heated under nitrogen, stirring and sonication. LGES-1001, 5:39-41. After heating the mixture for 1 hour at 140°C , a solution of 0.65 g of lithium acetate (lithium source) and 0.74 g of ammonium phosphate (phosphate source) in 4.2 ml of deionized water is added. *Id.* 5:42-44.

In contrast, in Step [2] of Cheng-Gan, a precursor dispersion is made by taking the mixture from Step [1] and “[m]ixing a lithium source, iron source, and phosphate salt ... **at one time, and simultaneously adding an organic carbon source.**” LGES-1007 ¶[0015]. A mixing and milling medium is then added to perform mixing and ball-milling for 6 to 24 hours. *Id.* The mixture is then dried at 60°C to 110°C to obtain precursor powder. *Id.* The organic carbon source mainly comprises sucrose, glucose, a phenolic resin, or the like. LGES-1007 ¶[0018].

Just like in Step [1], these are material differences and processes. MRD-2006 ¶¶228-230.

First, in Example 2 it is critical that the water-soluble iron acetate **is added independently** in the mixture of Step [1], and **not** simultaneously with the lithium acetate and ammonium phosphate. *Id.* ¶231 (citing LGES-1001, 5:39-41). This order of addition allows the lithium iron phosphate crystals to grow at the iron sites. *Id.* In contrast, in Cheng-Gan, the “lithium source, an iron source, and a phosphate salt” are mixed “**at one time, and simultaneously** adding an organic carbon source.” *Id.* (quoting LGES-1007 ¶¶[015]).

Second, Cheng teaches using ferric oxide. *Id.* ¶232 (citing LGES-1007 ¶[0041], [0057]). Because ferric oxide is insoluble in water, it will remain as insoluble particles in the Cheng-Gan dispersion, creating a non-uniform growth of lithium iron phosphate crystals on the CNTs, which will adversely affect their ability

to uniformly disperse. *Id.* Further, ferric oxide has higher density (5.24 g/cm³) than water (1.0 g/cm³), causing it to sink in the dispersion and hinder the CNTs' ability to uniformly disperse. *Id.* (citing MRD-2033).

Third, Example 2 does not use an organic carbon source. *Id.* ¶233 (citing LGES-1001, 5:36-53). In contrast, Cheng-Gan requires an organic carbon source, so that it can be converted to a carbon binder during calcination, also affecting dispersibility of the CNTs. *Id.* (citing LGES-1007 ¶¶[0014], [0018], [0041]). Thus, Step [2] of Cheng-Gan involves a binder material, whereas Step [2] of Example 2 does not. *Id.*

Step [3] heat treatment

Petitioner vaguely describes Step [3] of Cheng-Gan as a “heat treatment,” but this step is a carbon thermal reduction reaction involving calcination at extremely high temperatures for long periods of time. *Id.* ¶¶234-235 (citing LGES-1007 ¶¶[0019], [0039]).

Example 2 and Cheng-Gan use fundamentally different “heat treatment” processes in Step [3]. *Id.* ¶236. The heat treatment of Example 2 does not involve an in situ solid phase reaction, carbon thermal reduction, or a carbon source, nor does it involve calcining each. *Id.* (citing LGES-1001, 5:36-53; LGES-1007 ¶¶[0019], [0039]). Example 2's heat treatment is initially at 140°C ramped up to 185°C over

30 minutes, and then held at 185°C for 4 hours, followed by cooling, centrifugation, and a washing step. *Id.*

In contrast, Cheng-Gan's carbon thermal reduction involves calcining at **600°C to 850°C for 4 to 48 hours**, followed by pulverizing the burned material, and sieving to obtain its CNT/LiFePO₄ composite. *Id.* ¶237 (citing LGES-1007 ¶¶[0010], [0012], [0019]). The calcining converts the organic carbon source into carbon via a pyrolysis reaction and is necessary so the resulting carbon serves as a binder in the composite. *Id.* The calcining is also required to form the lithium iron phosphate. *Id.* Thus, the heating processes are fundamentally different.

Additionally, Petitioner fails to recognize that after calcining, the resultant CNT/LiFePO₄ composite would cool to room temperature. *Id.* ¶238. Due to the difference in the thermal expansion coefficient of carbon compared to the CNTs, the CNTs are pulled closer together, making them less dispersed, and helping to form the "continuous" network of CNTs sought by Cheng. *Id.* ¶¶239-242 (citing MRD-2040; MRD-2041).

Since each of step of Example 2 and Cheng-Gan are materially different, a POSITA would expect that the two final compositions would exhibit fundamentally different CNT dispersion results. *Id.* ¶243. Cheng-Gan results in a continuous network of CNTs, which is the result expressly sought by Cheng-Gan. *Id.* Petitioner's conclusory assertion that Cheng-Gan and Example 2 would achieve the

same “dispersion results”—simply because the respective steps are *generally* similar—is insufficient to demonstrate unpatentability. *Id.* Indeed, Dr. Zhu acknowledged that the three generalized steps are common to making electrodes. MRD-2026, 10:19-11:23. But such mixtures are often fundamentally different depending on the *specifics* of each step, undermining Petitioner’s “similarity” theory.

v. Petitioner’s “alternative” argument

Petitioner also offers the “alternative” argument that “a POSITA would have understood or found obvious that the nanotubes in the combination composition are **discrete** because, at least in some instances, oxidation of nanotubes can help promote **non-agglomeration of nanotubes.**” Pet., 54 (emphasis in original). However, the only evidence offered by Petitioner is that oxidation can help “inhibit[] aggregation of nanotubes into clumps.” *Id.* At best, this merely evidences that oxidation can help *disperse* CNTs—not that it results in *discrete* CNTs. *Id.* Indeed, CNTs can be uniformly dispersed throughout a composition to form a continuous network, but that does not mean they are “discrete.” MRD-2006 ¶244. Petitioner’s leap in logic—that “behavior of oxidized nanotubes” necessarily achieves discrete CNTs—is entirely unsupported. *Id.*; *See also* LGES-1005, 3 (top right of Fig. 2 showing oxidized CNTs that are still highly entangled).

5. Cheng and Gan teach away from “discrete” CNTs.

A POSITA “would be led in a direction divergent from the path that was taken by the” inventors, because Cheng and Gan seek a continuous or percolated network of CNTs to improve conductivity—the opposite objective of achieving discrete CNTs having active material attached to their surface (e.g., to retard cracking). *In re Gurley*, 27 F.3d at 553. Discrete CNTs could not form part of the “continuous” network of CNTs sought by Cheng or Gan. Indeed, Gan teaches that two goals of CNT functionalization is to “draw the CNTs ***closer together***” and “provide[]s a ***conductive bridge between CNTs*** to reduce the electrical contact resistance therebetween” MRD-2006 ¶¶245-246 (citing LGES-1021 ¶¶[0020], [0022]). These goals run contrary to the achieving “discrete” CNTs. *Id.* A POSITA would be discouraged from functionalizing CNTs as taught by Gan, because Gan teaches that functionalization would be less likely to result in discrete CNTs. *Id.* ¶247.

VII. Conclusion

For the reasons above, Petitioner fails to prove that any claim is unpatentable.

Dated: March 31, 2025

Respectfully submitted,

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CERTIFICATE OF COMPLIANCE

The undersigned certifies that this document complies with the type-volume limitations set forth in 37 C.F.R. § 42.24 *et seq.* This document, excluding those portions excluded under § 42.24(a)(1), contains 13,994 words as calculated by the program used in creating it.

/Stephen D. Zinda/

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CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 42.6(e)(4), the undersigned certifies that on March 31, 2025, a copy of the foregoing document (*Patent Owner's Response*, including all Exhibits), was served via electronic mail on all attorneys of record at the email addresses provided for electronic service listed in Petitioner's mandatory notices, as set forth below:

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