

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Clive P. Bosnyak, et al.
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Filing Date: October 7, 2016
Title: DISPERSIONS COMPRISING DISCRETE CARBON
NANOTUBE FIBERS

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**PETITION FOR *INTER PARTES* REVIEW OF UNITED STATES PATENT
NO. 9,636,649 PURSUANT TO 35 U.S.C. §§ 311–319, 37 C.F.R. § 42**

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	REQUIREMENTS FOR IPR	2
	A. Grounds for Standing.....	2
	B. Challenge and Relief Requested.....	2
III.	SUMMARY OF THE '649 PATENT	4
	A. Brief Description.....	4
	B. Prosecution History.....	4
	C. Level of Ordinary Skill in the Art.....	5
	D. Claim Construction	5
IV.	THE CHALLENGED CLAIMS ARE UNPATENTABLE.....	6
	A. [GROUND 1A] – CLAIMS 1-7, 11, 13-14, 17-19 ARE OBVIOUS OVER SUN.....	6
	1. Sun describes both an aqueous dispersion of carbon nanotubes and an epoxy-nanotube composite.....	6
	2. Analysis	8
	B. [GROUND 1B] – CLAIM 8 IS OBVIOUS OVER SUN AND BURETEA	34
	1. Buretea describes nanotube-resin composites including plasticizers	34
	2. The Sun-Buretea combination.....	34
	3. Reasons for the combination	34
	4. Analysis	36
	C. [GROUND 1C] – CLAIMS 9-10, 15, AND 21-23 ARE OBVIOUS OVER SUN AND KAJI	38
	1. Kaji describes nanotube-resin composites including carnauba wax and silicone oil additives	38
	2. The Sun-Kaji combination	39
	3. Reasons for the combination	39
	4. Analysis	41
	D. [GROUND 1D] – CLAIMS 16 AND 20 ARE OBVIOUS OVER SUN, KAJI, AND MATSUSHITA	43
	1. Matsushita describes nanocomposites including fluororubber	43
	2. Sun-Kaji-Matsushita provides a nanocomposite including a fluororubber.....	43

3.	Reasons for the combination	44
4.	Analysis	45
E.	[GROUND 2A] – CLAIMS 1-8, 11-15, 17-19, AND 21 ARE OBVIOUS OVER FARRUGIA AND NARAYAN	46
1.	Farrugia describes toners including electrically conductive nanotube/polymer composites	46
2.	Narayan describes electrically conductive carbon nanotube/polymer compositions	48
3.	The Farrugia-Narayan combination	48
4.	Reasons for the combination	49
5.	Analysis	52
F.	[GROUND 2B] – CLAIMS 22-23 ARE OBVIOUS OVER FARRUGIA, NARAYAN, AND NANYA	75
1.	Nanya describes toners including lubricants	75
2.	The Farrugia-Narayan-Nanya combination	76
3.	Reasons for the combination	76
4.	Analysis	78
V.	PTAB DISCRETION SHOULD NOT PRECLUDE INSTITUTION	78
A.	The <i>Fintiv</i> Factors Favor Institution—§314(a)	78
B.	The <i>Advanced Bionics</i> Test Favors Institution—§ 325(d)	79
VI.	PAYMENT OF FEES – 37 C.F.R. § 42.103	80
VII.	CONCLUSION	80
VIII.	MANDATORY NOTICES UNDER 37 C.F.R § 42.8(a)(1)	80
A.	Real Party-In-Interest Under 37 C.F.R. § 42.8(b)(1)	80
B.	Related Matters Under 37 C.F.R. § 42.8(b)(2)	80
C.	Lead And Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3)	81
D.	Service Information	81

EXHIBITS

LGES-1001	U.S. Patent No. 9,636,649 (“the ’649 Patent”)
LGES-1002	Excerpts from Prosecution History of the ’649 Patent (“the Prosecution History”)
LGES-1003	Declaration of Dr. Samuel P. Gido
LGES-1004	U.S. Patent Pub. No. 2010/0197832 (“Sun”)
LGES-1005	U.S. Patent No. 7,091,120 (“Buretea”)
LGES-1006	U.S. Patent Pub. No. 2010/0016473 (“Kaji”)
LGES-1007	U.S. Patent Pub. No. 2010/0124713 (“Farrugia”)
LGES-1008	U.S. Patent Pub. No. 2003/0213939 (“Narayan”)
LGES-1009	U.S. Patent No. 5,079,123 (“Nanya”)
LGES-1010	U.S. Patent Pub. No. 2010/0009165 (“Patel”)
LGES-1011	U.S. Patent Pub. No. 2011/0272856 (“Rasmussen”)
LGES-1012	U.S. Patent Pub. No. 2008/0315453 (“Molitor”)
LGES-1013	Japanese Unexamined Patent Application No. 2009-235650 (“Matsushita”)
LGES-1014	“Surface modified multi-walled carbon nanotubes in CNT/epoxy-composites.” Florian H. Gojny, Jacek Nastalczyk, Zbigniew Roslaniec, Karl Schulte. Chemical Physics Letters 370 (2003) 820–824 (“Gojny”)
LGES-1015	“Sonochemical Oxidation of Multiwalled Carbon Nanotubes.”

Yangchuan Xing, Liang Li, Charles C. Chusuei, and Robert V.

Hull. *Langmuir* 2005, 21, 4185-4190 (“Xing”)

LGES-1016 U.S. Patent No. 7,807,127 (“Forohar”)

LGES-1017 U.S. Patent Pub. No. 2009/0168301 (“Viswanathan”)

LGES-1018 Reserved

LGES-1019 U.S. Patent Pub. No. 2010/0006152 (“Hatton”)

LGES-1020 U.S. Patent No. 9,327,054 (“Sundara”)

LGES-1021 U.S. Patent Pub. No. 2012/0058255A1 (“Gan”)

LGES-1022 U.S. Patent Pub. No. 2007/0259994 (“Tour”)

LGES-1023 Reserved

LGES-1024 EP Patent No. EP 2 139 630 (“Bergmark”)

LGES-1025 U.S. Patent No. 7,163,973 (“Ahsan”)

LGES-1026 U.S. Patent No. 7,846,998 (“Akagi”)

LGES-1027 U.S. Patent Pub. No. 2006/0014873 (“Ikezawa”)

LGES-1028 U.S. Patent Pub. No. 2011/0183253 (“Aga”)

LGES-1029 U.S. Patent No. 3,471,395 (“Sumner”)

LGES-1030 U.S. Patent No. 4,625,761 (“Uchida”)

LGES-1031 “Characterization of Zirconium Phosphate/Polycation Thin Films Grown by Sequential Adsorption Reactions” Hyuk-Nyun Kim, Steven W. Keller, Thomas E. Mallouk, Johannes Schmitt, and Gero Decher. *Chem. Mater.*, Vol. 9, No. 6, 1997

LGES-1032 “The IUPAC Rules for Naming Organic Molecules” Stanislaw Skonieczny. *Journal of Chemical Education*. Vol. 83 No. 11, pp.

	1633-1637 (2006) (“Skonieczny”)
LGES-1033	U.S. Patent No. 8,282,725 (“Shimomura”)
LGES-1034	U.S. Patent No. 6,569,231 (“Mathias”)
LGES-1035	Reserved
LGES-1036	U.S. Patent No. 7,749,682 (“Miyabe”)
LGES-1037	U.S. Patent No. 7,959,280 (“Koike”)
LGES-1038	U.S. Patent No. 6,544,326 (“Itou”)
LGES-1039	U.S. Patent No. 5,458,681 (“Hasegawa”)
LGES-1040	U.S. Patent No. 5,750,304 (“Yamaguchi”)
LGES-1041	A. Hirsch. “Functionalization of Single-Walled Carbon Nanotubes” <i>Angew. Chem. Int. Ed.</i> 2002, 41, No. 11, 1853-1859
LGES-1042	N. Canter. “Mold-release agents and coatings.” <i>Tribology & Lubrication Technology</i> 2008, 31-38 (“Canter”)
LGES-1043	J.E. Plevyak and L.A. Sobieski. “Improved RIM Processing with Silicone Internal Mold Release Technology.” <i>Journal of Cellular Plastics</i> 1984, 363-368 (“Plevyak”)
LGES-1044	Reserved
LGES-1045	B.D. Cullity. “Elements of X-Ray Diffraction.” Addison-Wesley Publishing Company, Inc. 1978. P. 86-87 (“Cullity”)
LGES-1046	U.S. Patent Pub. No. 2009/0200517 (“El Bounia”)
LGES-1047	P. C. Hiemenz, T.P. Lodge. “Polymer Chemistry, Second Edition.” CRC Press 2007. Chapters 2 and 10 (“Hiemenz”)
LGES-1048	J. Mijovic, E. M. Pearce, and C.-C. Foun. “Fluoroelastomer-

Modified Thermoset Resins.” *Advances in Chemistry*; American
Chemical Society 1984, 293-307 (“Mijovic”)

- LGES-1049 U.S. Patent No. 4,421,878 (“Close”)
- LGES-1050 *Molecular Rebar Design, LLC, and Black Diamond Structures, LLC v. LG Energy Solution, Ltd.*, Plaintiffs’ Disclosure of Asserted
Claims and Infringement, 2:24-cv-00107-JRG
- LGES-1051 U.S. Patent Pub. No. 2006/0124028 (“Huang”)
- LGES-1052 Reserved
- LGES-1053 *Molecular Rebar Design, LLC, et al. v. LG Energy Solution, Ltd.*,
Sample Docket Control Order, 2:24-cv-00107-JRG

CLAIM LISTING

Limitation	Claim Language
[1pre]	A dispersion comprising
[1a]	a plurality of oxidized, discrete carbon nanotubes and
[1b]	at least one additive
[1c]	wherein the oxidized, discrete carbon nanotubes have an aspect ratio of 25 to 500,
[1d]	are multiwall, and
[1e]	are present in the range of greater than zero to about 30% by weight based on the total weight of the dispersion.
[2]	The dispersion of claim 1 wherein at least 70 percent by weight of the nanotubes are discrete.
[3]	The dispersion of claim 1 in the form of free flowing particles.
[4]	The dispersion of claim 1 wherein the oxidized, discrete carbon nanotubes comprise an oxidation species selected from carboxylic acid or a derivative carbonyl containing species wherein the derivative carbonyl species is selected from ketones, quaternary amines, amides, esters, acyl halogens, and monovalent metal salts.
[5]	The dispersion of claim 1 wherein the oxidized, discrete carbon nanotubes comprise an oxidation species selected from hydroxyl or derived from hydroxyl containing species.
[6]	The dispersion of claim 1 wherein the oxidized, discrete carbon nanotubes are present in the range of 15% to about 25% by weight based on the total weight of the dispersion.
[7]	The dispersion of claim 1 wherein the oxidized, discrete carbon nanotubes are present in the range of 18% to about 22% by weight based on the total weight of the dispersion.
[8]	The dispersion of claim 1, wherein the additive is selected from the group consisting of dicarboxylic/tricarboxylic esters, timellitates, adipates, sebacates, maleates, glycols and polyethers, polymeric plasticizers, bio-based plasticizers, and mixtures thereof.
[9]	The dispersion of claim 1, wherein the additives is a process oil.

Limitation	Claim Language
[10]	The dispersion of claim 9, where in the process oil is selected from the group consisting of naphthenic oils, paraffin oils, paraben oils, aromatic oils, vegetable oils, seed oils, silicones, and mixtures thereof.
[11]	The dispersion of claim 1, wherein the additive is a solvent.
[12]	The dispersion of claim 11, where in the solvent is selected from the group consisting of substituted or unsubstituted, halogenated or nonhalogenated hydrocarbons.
[13]	The dispersion of claim 1, wherein the additive comprises at least one reactive species capable of creating a thermoset polymer.
[14]	The dispersion of claim 13, wherein the thermoset polymer is selected from epoxy, polyurethane and silicone.
[15]	The dispersion of claim 1, wherein the additive comprises natural wax, synthetic wax, or mixtures thereof.
[16]	The dispersion of claim 15 further comprising a fluoroelastomer.
[17]	The dispersion of claim 1 which further comprises at least one filler.
[18]	The dispersion of claim 17, wherein the filler has at least one dimension less than about 20 microns.
[19]	The dispersion of claim 18, wherein the filler is selected from silicon, lead, lead derivatives, carbon black, graphite, graphene, graphene oxides, paramagnetic particles and mixtures thereof.
[20pre]	A dispersion comprising
[20a]	a plurality of oxidized, discrete carbon nanotubes and
[20b]	at least one wax additive and
[20c]	at least one fluoroelastomer,
[20d]	wherein the discrete carbon nanotubes have an aspect ratio of 25 to 500, are multiwall, and are present in the range of greater than zero to about 30% by weight based on the total weight of the dispersion.
[21]	The dispersion of claim 15 which further comprises a crosslinking agent.

Limitation	Claim Language
[22]	The dispersion of claim 15 wherein the additive comprises natural wax wherein the natural wax is plant derived.
[23]	The dispersion of claim 22 which further comprises a crosslinking agent.

I. INTRODUCTION

LG Energy Solution, Ltd. (“Petitioner”) petitions for IPR of claims 1-23 (“Challenged Claims”) of U.S. Patent No. 9,636,649 (“the ’649 Patent”).

The ’649 Patent describes its purported “invention” as relating to “carbon nanotubes as composites with materials such as elastomers, thermosets and thermoplastics or aqueous dispersions of open-ended carbon nanotubes with additives.” LGES-1001, Abstract. By contrast, the Challenged Claims of the ’649 Patent are generic, reciting merely that a dispersion includes oxidized, discrete, and multiwall carbon nanotubes and an additive. *Id.*, 13:50-55. Such a dispersion was well-known in the art. And although the ’649 claims recite certain characteristics of its dispersion—*e.g.*, that the nanotubes have an aspect ratio in a specified range, and are present in the dispersion in a specified range of weight percentages—these features, too, were not new. *Id.*, 13:50-55. More, while the ’649 claims recite specific ranges of values for these characteristics, the ’649 Patent itself fails to demonstrate, or even suggest, that these ranges of aspect ratios and weight percentages are in any way critical to its dispersion, instead merely providing a list of example ranges with no indication of the relevance of any of the claimed ranges. *See* LGES-1001, 5:18-24, 8:19-28.

II. REQUIREMENTS FOR IPR

A. Grounds for Standing

Petitioner certifies that the '649 Patent is available for IPR. Petitioner is not barred or estopped from requesting this review.

B. Challenge and Relief Requested

Petitioner requests IPR of the Challenged Claims on the below grounds.

LGES-1003, ¶¶1-330.

Ground	Claims	Basis for Rejection
1A	1-7, 11, 13-14, 17-19	§103: Sun
1B	8	§103: Sun and Buretea
1C	9-10, 15, 21-23	§103: Sun and Kaji
1D	16, 20	§103: Sun, Kaji, and Matsushita
2A	1-8, 11-15, 17-19, 21	§103: Farrugia and Narayan
2B	22-23	§103: Farrugia, Narayan, and Nanya

Each applied reference pre-dates December 14, 2010 (“Critical Date”), which is the earliest filed application from which the '649 Patent claims priority. Petitioner does not take a position as to whether the '649 Patent is entitled to priority to the Critical Date, but has applied references that pre-date the Critical

Date and qualify as prior art, as shown below.¹

Reference	Date	Section
Sun	2/2/2010 (filed) 8/5/2010 (published)	§§102(a), 102(e)
Buretea	8/15/2006 (issued)	§102(b)
Kaji	5/7/2009 (filed) 1/21/2010 (published)	§§102(a), 102(e)
Matsushita	10/15/2009 (published)	§102(b)
Farrugia	11/17/2008 (filed) 5/20/2010 (published)	§§102(a), 102(e)
Narayan	11/20/2003 (published)	§102(b)
Nanya	1/7/1992 (issued)	§102(b)

¹ In the May 15, 2024 infringement contentions in the co-pending district court case, Patent Owner alleges 36 alternative priority dates that the '649 Patent may be entitled to. LGES-1050, 7-9. While such allegations do not appear to be justified—among other things because of failure to demonstrate possession of the aspect ratio and weight percentage features as claimed—Petitioner reserves the right to respond to any such similar allegations made in this IPR proceeding.

III. SUMMARY OF THE '649 PATENT

A. Brief Description

The '649 Patent relates to “Dispersions Comprising Discrete Carbon Nanotube Fibers.” LGES-1001, Abstract. The claims of the '649 Patent recite merely that a dispersion includes oxidized, discrete, and multiwall carbon nanotubes and an additive. *Id.*, 13:50-55; LGES-1003, ¶22. Such dispersions were well known, as were the particular aspect ratio weight percentage characteristics also recited in the claims. LGES-1003, ¶23.

B. Prosecution History

The '649 Patent issued from U.S. Patent App. No. 15/288,553. No office actions were issued. The first substantive action was a Notice of Allowance, referencing an examiner-initiated interview in which the examiner requested the filing of a Terminal Disclaimer over parent application 15/255,215 (the “'215 application”) and re-submission of a declaration of Dr. Henderson from the '215 application. LGES-1002, 14-24. Dr. Henderson’s declaration addressed the claims of the '215 application in view of rejections over Tour (US 2007/0259994) and Bhattacharyya (Carbon 2008, Vol. 46, pp. 1037-45). *Id.*, 78-83. In the interview, the applicant authorized an Examiner’s Amendment, changing the phrase “up to about 30%” to “present in the range of greater than zero to about

30%.” *Id.*, 18. The reasons for allowance, citing Dr. Henderson’s declaration, state that “the express method taught by Tour for multiwall carbon nanotubes does not yield multiwall discrete carbon nanotubes,” and that “Bhattacharyya et al. does not teach or suggest discrete carbon nanotubes.” *Id.*, 22-23.

C. Level of Ordinary Skill in the Art

A person of ordinary skill in the art relating to the subject matter of the ’649 Patent as of the Critical Date (a “POSITA”) would have had at least Master’s degree in materials science, chemistry, chemical engineering, a field relevant to polymer science and engineering, or the equivalent, and at least three years of experience in nanomaterials, electrochemistry, batteries, or polymer related activities. Additional work experience can compensate for less formal education, and vice versa. LGES-1003, ¶19.

D. Claim Construction

Based on the prior art’s description of the claimed elements being similar to that of the ’649 Patent specification, no formal claim constructions are necessary in this proceeding because “claim terms need only be construed to the extent necessary to resolve the controversy.” *Wellman, Inc. v. Eastman Chem. Co.*, 642 F.3d 1355, 1361 (Fed. Cir. 2011).

IV. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. [GROUND 1A] – CLAIMS 1-7, 11, 13-14, 17-19 ARE OBVIOUS OVER SUN

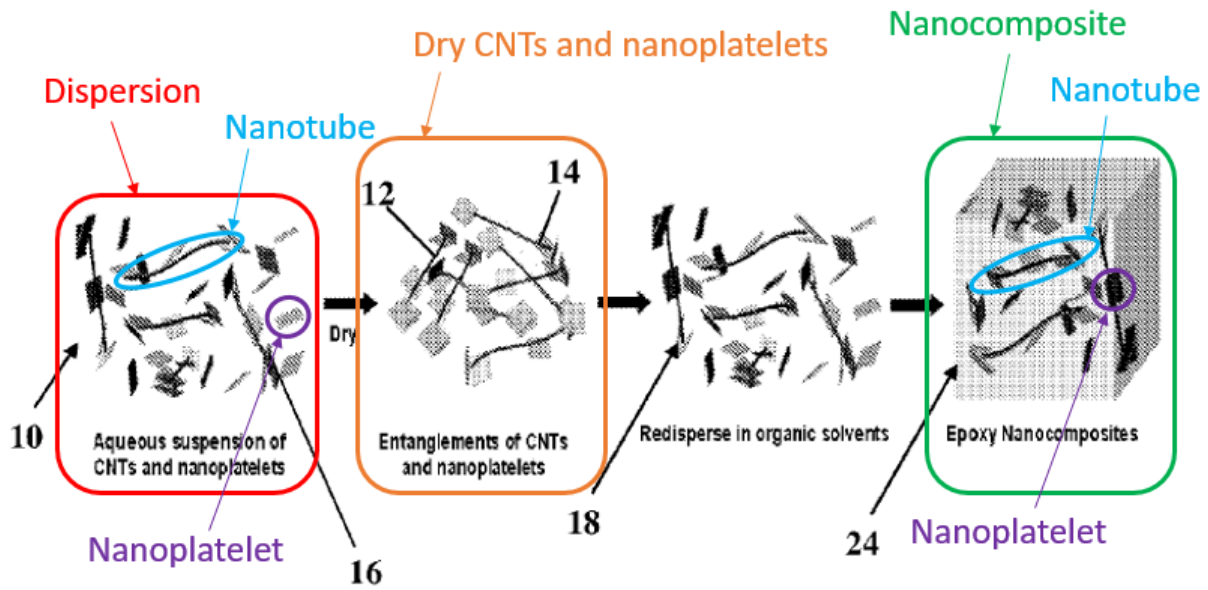
1. Sun describes both an aqueous dispersion of carbon nanotubes and an epoxy-nanotube composite²

Sun describes a “drying-redispersion method to disperse carbon nanotubes and inorganic nanoparticles into epoxy to form exfoliated epoxy nanocomposites” “containing ... well-dispersed carbon nanotubes.” LGES-1004, [0072]; LGES-1003, ¶25.

Sun’s describes generating a “dispersion 10,” red in Fig. 1, *infra*, by mixing “[o]xidized, suspended carbon nanotubes (CNTs) 12” (blue) with “aqueous solutions of nanoplatelets 14” (purple). LGES-1004, [0036]. The “dispersion of nanotubes is attributed to the presence of the nanoplatelets.” *Id.*, [0044].

Specifically, “[t]he nanoplatelets force the nanotube bundles into individual tubes,” and “[t]he surface charge and two-dimensional nature of exfoliated nanoplatelets disperse the nanotubes and hinder the re-aggregation thereof.” *Id.*; LGES-1003, ¶26-27.

² Petitioner incorporates this discussion into Grounds 1A-1D.



Sun, Fig. 1 (annotated)

The aqueous dispersion of nanotubes and nanoplatelets (referred to as nanofiller) is dried, and later used for “further dispersion 18 in solvents.” LGES-1004, [0068]; *see* [0047]-[0048]. For instance, the nanofiller is “dispersed in a medium such as ... epoxy, plastic, or polymer, to form a nanocomposite 24,” green. *Id.*, [0045]; *see* [0052]. The nanocomposite is cured: “a curing agent is added to the epoxy and nanotubes, and heated to polymerize, crosslink, vulcanize, or otherwise cure ... the epoxy nanocomposite.” *Id.*, [0046]; *see* [0052]. The cured nanocomposite contains “[w]ell-dispersed” nanotubes and nanoplatelets, both of which are “fully dispersed down to individual level in epoxy matrices.” *Id.*, [0069]; LGES-1003, ¶28.

As demonstrated *infra*, the dispersion of the Challenged Claims is rendered obvious by either Sun's aqueous dispersion or Sun's nanocomposite. See LGES-1004, [0043]-[0046], FIG. 1; LGES-1003, ¶29.

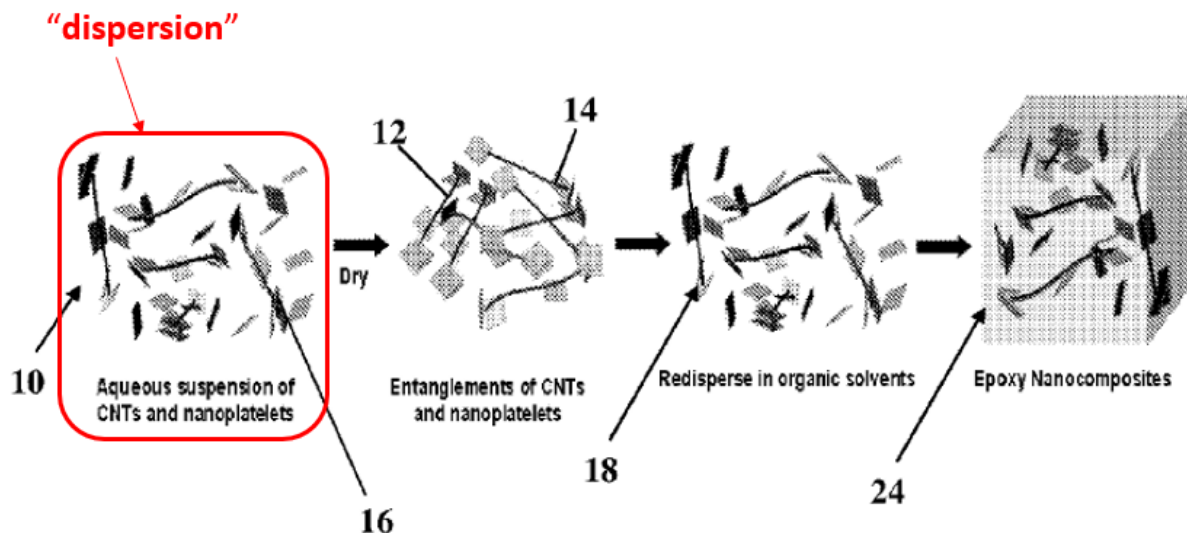
2. Analysis

(i) Claim 1

[1pre]

To the extent the preamble is deemed to be limiting, Sun renders it obvious. LGES-1003, ¶¶30-36.

Sun's aqueous dispersion is a dispersion

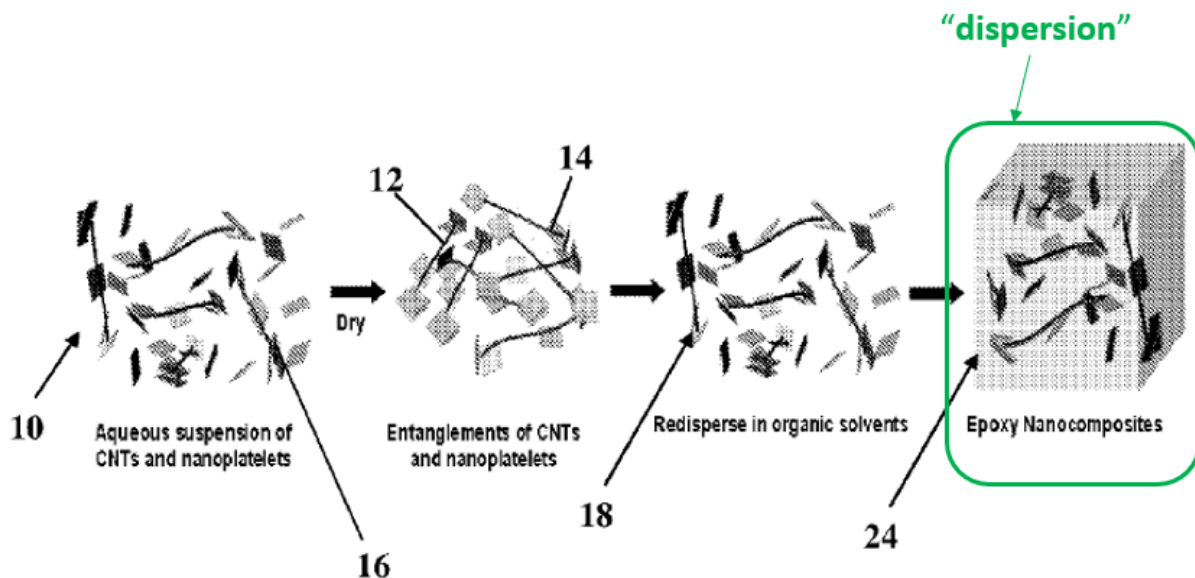


Sun, Fig. 1 (annotated)

Sun's "aqueous nanotube-nanoplatelet *dispersion*" is a **dispersion**. LGES-1004, [0043]; LGES-1003, ¶31. This dispersion (*e.g.*, dispersion 10, red in FIG. 1, *supra*), is "a substantially homogeneous solution of dispersed nanotubes 12 and associated nanoplatelets 14." LGES-1004, [0043]; *see* [0036] ("the electrostatic

association of nanotubes 12 and nanoplatelets 14 in solutions or solvents 18 form **a dispersion 10**”), [0042], [0056] (“Two Aqueous solutions containing oxidized MWNTs and fully exfoliated ZrP nanoplatelets were directly mixed. ... **After dispersion**, the aqueous mixtures were dried”), [0044], [0068]-[0069], Abstract, [0036], [0032], [0011]; LGES-1003, ¶¶31-32.

Sun’s epoxy nanocomposite is a dispersion



Sun, Fig. 1 (annotated)

Alternatively/additionally, Sun’s nanocomposite is **a dispersion**. LGES-1003, ¶33. Sun describes forming “**nanocomposite 24**” by “dispers[ing]” nanofiller containing nanotubes and nanoplatelets “in a medium such as ... epoxy, plastic, or polymer.” LGES-1004, [0045]-[0046]. This nanocomposite, green in FIG. 1, *supra*, is **a dispersion** at least because the nanotubes and nanoplatelets are dispersed in the matrix medium of the nanocomposite. *See id.*, [0014] (“FIG. 1

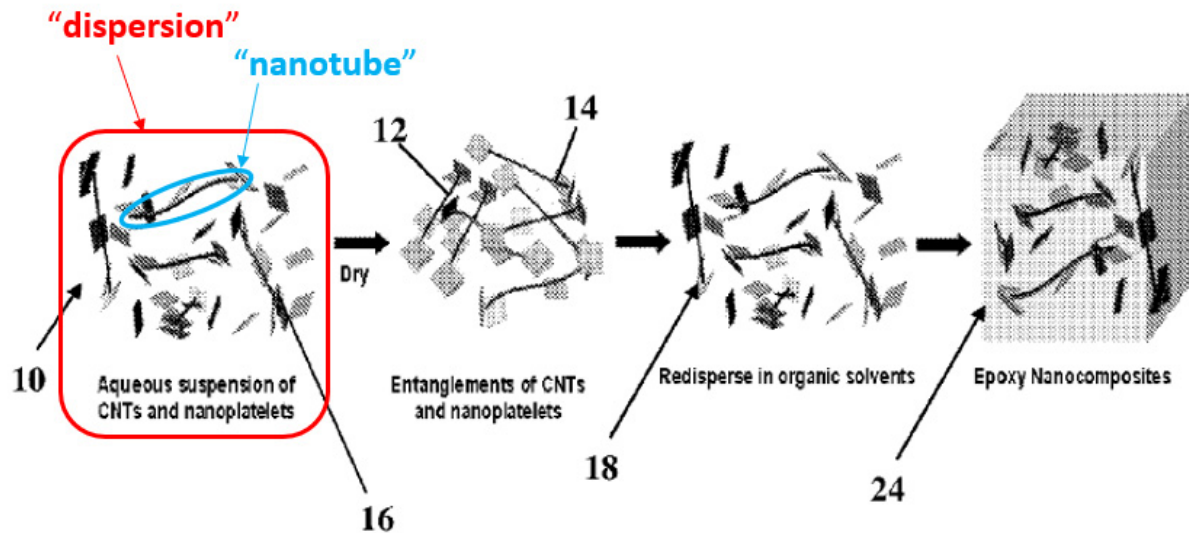
illustrates a conceptual scheme for the preparation of *epoxy nanocomposites containing individual dispersed CNTs* and exfoliated nanoplatelets”), [0068] (“The concept for *re-dispersing* exfoliated nanoplatelets and carbon nanotubes in polymers is summarized in FIG. 1”), [0036], [0032]; *see also* [0052]; LGES-1003, ¶33.

Specifically, a precursor, such as “an epoxy,” is mixed into a suspension of nanotubes and nanoplatelets in acetone, forming an uncured mixture. LGES-1004, [0045]; *see* [0062] (“improved steps for *redispersing MWNTs* and exfoliated ZrP *into epoxy* to form exfoliated nanocomposites”); *see also* [0052]. The solvent is removed and the nanofiller-epoxy mixture is cured in the presence of a “curing agent” to form a cured nanocomposite. *Id.*, [0046]; *see* [0052]. Notably, both the uncured mixture of nanotubes and precursor (*e.g.*, before or after solvent removal) and the cured nanocomposite are **dispersions**, at least because the nanotubes are dispersed in the precursor and are also dispersed in the cured matrix material. *See id.*, [0014] (“*epoxy nanocomposites containing individual dispersed CNTs* and exfoliated nanoplatelets”), Abstract, [0069], claims 30-31, [0045]-[0046], [0052], [0062], FIG. 6; LGES-1003, ¶¶34-36.

[1a]

Sun's aqueous dispersion includes oxidized, discrete carbon nanotubes

First, Sun's "aqueous nanotube-nanoplatelet dispersion" includes a **plurality of carbon nanotubes**: "[o]xidized, suspended *carbon nanotubes (CNTs) 12*," blue in FIG. 1, *infra*. LGES-1004, [0036], [0043]; *see* [0037]-[0038], [0068] (an "aqueous suspension 10, containing *dispersed CNTs 12*"), claims 13-14, [0031], [0042]-[0044], claims 20 and 27; LGES-1003, ¶¶37-38.



Except from Sun, FIG. 1 (annotated)

Second, the carbon nanotubes in the aqueous dispersion are **oxidized**. Sun describes that the nanotubes in the dispersion 10 are "[o]xidized, suspended carbon nanotubes." LGES-1004, [0036]; *see* [0042] ("the aqueous-*oxidized nanotube* solution, and aqueous-exfoliated nanoplatelet solution are admixed ... to form a

dispersion 10”), [0039], [0054]-[0057], [0044], claim 16, claim 20; LGES-1003, ¶¶39-40.

Third, a POSITA would have understood or found obvious that the oxidized nanotubes in Sun’s aqueous dispersion are **discrete**, *e.g.*, based on Sun’s description of the structure of the aqueous dispersion. LGES-1003, ¶¶41-44. In the aqueous dispersion, “the nanoplatelets attach to the nanotube walls, and at least partially enter between nanotubes of the bundles.” LGES-1004, [0044]. Then, “[t]he nanoplatelets *force the nanotube bundles into individual tubes*,” such that “the nanoplatelets have *individual, exfoliated, or separated tubes* attached, or tethered to the surfaces of the nanoplatelets.” *Id.*; *see id.* (“The nanotubes dispersed by the nanoplatelets are *exfoliated*,” where “‘exfoliated’ as used herein refers to *individually dispersed*, or monodisperse nanotubes,” *id.*, [0033]), [0042], FIG. 5; LGES-1003, ¶42.

The use of nanoplatelets in the aqueous dispersion to “force the nanotube bundles into individual tubes,” *e.g.*, to “disperse the oxidized nanotubes. LGES-1004, [0042], [0044]; *see* [0068], FIGS. 1 and 5; LGES-1003, ¶¶42-44. In this context, it would have been obvious to a POSITA from Sun to create a dispersion with at least some nanotubes that are generally individually distinct, *e.g.*, lacking direct association with other nanotubes along substantially the length of the

nanotubes, consistent with this described use of the nanoplatelets.³ LGES-1003,

¶¶42-44. To the extent **discrete** is interpreted as referring to nanotubes that are generally individually distinct, a POSITA would have found it obvious that Sun's dispersion contains at least some **discrete** nanotubes. *Id.*

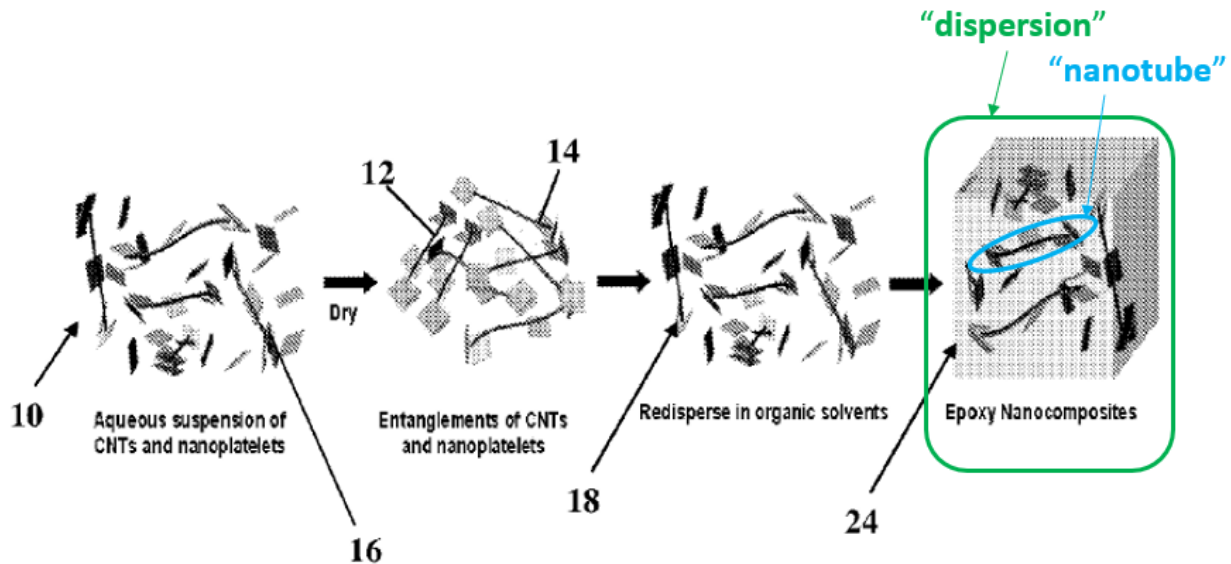
Alternatively/additionally, a POSITA would have understood or found obvious that the nanotubes in Sun's aqueous dispersion are **discrete** because, at least in some instances, oxidation of nanotubes can help promote non-agglomeration of the nanotubes. LGES-1003, ¶¶45-55. Sun's nanotubes are oxidized in "a mixture of sulfuric acid and nitric acid" in a 1:3 ratio. LGES-1004, [0039]; *see* [0054]. A POSITA would have known that oxidation of carbon nanotubes under these conditions can result in surface functionalization, *e.g.*, with species such as carboxylic acid or hydroxyl groups. *See* LGES-1014, 821-822; LGES-1015, 4186-4187; LGES-1007, [0027]-[0028]; LGES-1016, 7:22-28, 13:40-45; LGES-1019, [0062], [0080]; LGES-1020, 8:54-58; LGES-1021, [0023]; LGES-1003, ¶¶46-55. As indicated by these references and as described by Dr. Gido, oxidized nanotubes can be physically and chemically inhibited from

³ The '649 Patent describes "carbon nanotube fibers" that "are essentially discrete individual fibers, not entangled as a mass." LGES-1001, 5:37-40; LGES-1003, ¶43.

aggregation into clumps; instead, oxidized nanotubes generally can be present as individually distinct nanotubes. LGES-1003, ¶¶47-55. In light of this behavior of oxidized nanotubes, a POSITA would have understood or found obvious that Sun's oxidized nanotubes can be present in the dispersion as generally individually distinct nanotubes, *e.g.*, nanotubes in the dispersion are **discrete**. LGES-1003, ¶¶45-55.

Sun's nanocomposite includes oxidized, discrete carbon nanotubes

First, Sun's nanocomposite **includes a plurality of oxidized carbon nanotubes**. The nanocomposite (green in Fig. 1, *infra*) includes the same nanotubes from the aqueous dispersion—*i.e.*, oxidized carbon nanotubes, as discussed *supra*—and thus the nanotubes (blue) in the nanocomposite are also **oxidized carbon nanotubes**. *See* [0043] (“[t]he nanotube-nanoplatelet association” of the dispersion 10 “comprises a nanofiller 16,” which “may be dispersed in a medium ... to form a nanocomposite 24”), [0036], [0046], [0044], [0054]-[0058], [0068]-[0069], claim 13; *see also* [0052], claim 20; LGES-1003, ¶¶56-57.



Except from Sun, FIG. 1 (annotated)

Second, a POSITA would have understood or found obvious that nanotubes in the nanocomposite are **discrete**. LGES-1003, ¶¶58-61. Sun’s nanocomposites “contain[] *individually dispersed CNTs*,” *e.g.*, generally individually distinct nanotubes (*e.g.*, **discrete** nanotubes, to the extent that **discrete** is interpreted as referring to generally individually distinct nanotubes). LGES-1004, [0014]; *see* Abstract (“the nanocomposite comprises ... at least one nanotube,” where “the nanotube comprises at least one *exfoliated* nanotube”), [0033], [0010]; claims 1, 5, 9, 11, 30-31; LGES-1003, ¶¶58-59.

Moreover, Sun’s experimental TEM images confirm that nanotubes in the nanocomposite are **discrete**, showing that “both MWNTs and nanoplatelets *can be fully dispersed down to individual level* in epoxy matrices.” LGES-1004, [0069], FIG. 6; LGES-1003, ¶60.

Alternatively/additionally, as discussed *supra*, a POSITA would have understood or found obvious that nanotubes in Sun's nanocomposite are **discrete** because they are the same oxidized nanotubes as those in the aqueous dispersion, and at least in some instances, the POSITA would have recognized that oxidation of nanotubes can help promote non-agglomeration of the nanotubes. *See* LGES-1004, [0039], [0054]; LGES-1003, ¶61.

[1b]

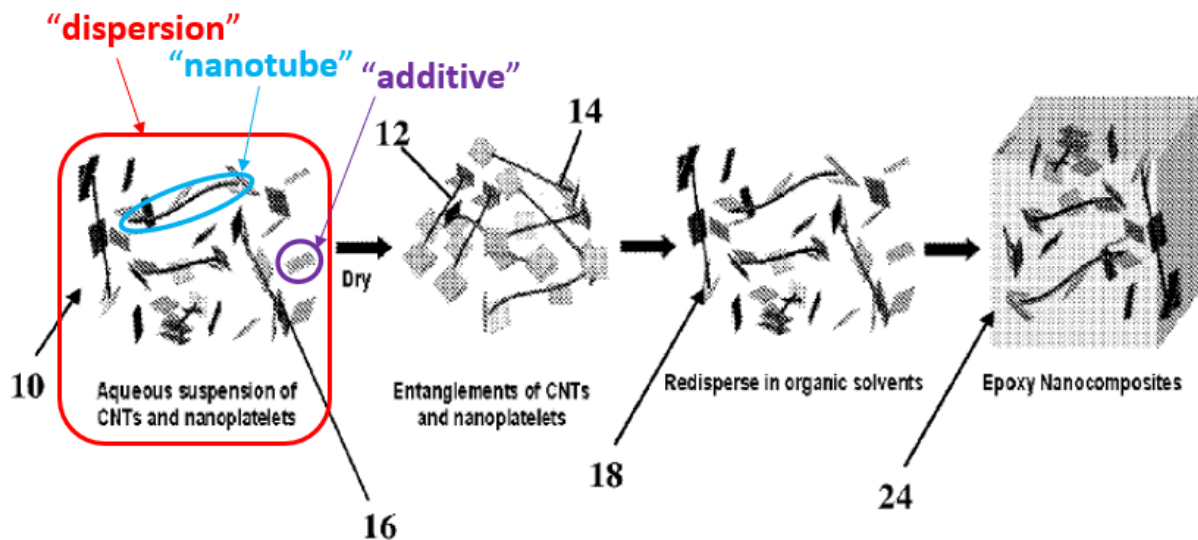
Sun renders obvious that the aqueous dispersion includes an additive

As one example of **an additive**, Sun's dispersion includes "nanotubes 12 and nanoplatelets 14 *in solutions or solvents*." LGES-1004, [0036]; *see* Fig. 1. A POSITA would have recognized that the solvent in the dispersion can correspond to **an additive**.⁴ LGES-1003, ¶63. For instance, the dispersion is an "aqueous solution," *e.g.*, water (the solvent) is **an additive**. *Id.*, [0036]; *see* [0042], [0043] ("the *aqueous* nanotube-nanoplatelet dispersion 10"), [0056], [0068] ("the *aqueous suspension* 10, containing dispersed CNTs 12"), FIG. 1, claim 13, claim 20; LGES-1003, ¶¶62-63.

⁴ The '649 Patent identifies solvents as additives. *See* LGES-1001, 7:46-53, claims 11-12; LGES-1003, ¶63.

As a second example, Sun describes an embodiment in which “*at least one surfactant is added* to the nanotube-nanoplatelet mixture,” *i.e.*, to the aqueous dispersion. LGES-1004, [0047]. A POSITA would have recognized that the surfactant can correspond to **an additive** in the dispersion. *See id.*, [0047], [0057]; LGES-1003, ¶64.

As a third example, a POSITA would have recognized that the nanoplatelets in Sun’s aqueous dispersion can correspond to **an additive**: “nanotubes 12 and *nanoplatelets* 14 in solutions or solvents 18 forms a dispersion 10.” LGES-1004, [0036]; *see* [0040]-[0044], [0047], [0055]-[0056], [0068], claims 16-18, FIG. 1 (*infra*); LGES-1003, ¶¶65-66.



Except from Sun, FIG. 1 (annotated)

Sun renders obvious that the nanocomposite includes an additive

As one example, Sun describes that the “nanofiller may be ***dispersed in a medium*** such as ... epoxy, plastic, or polymer, to form” the nanocomposite. LGES-1004, [0045]; *see* [0014], [0058], Abstract. A POSITA would have recognized that the medium—*e.g.*, epoxy, plastic, or polymer—in which the nanofiller is dispersed can correspond to **an additive**. LGES-1003, ¶67.

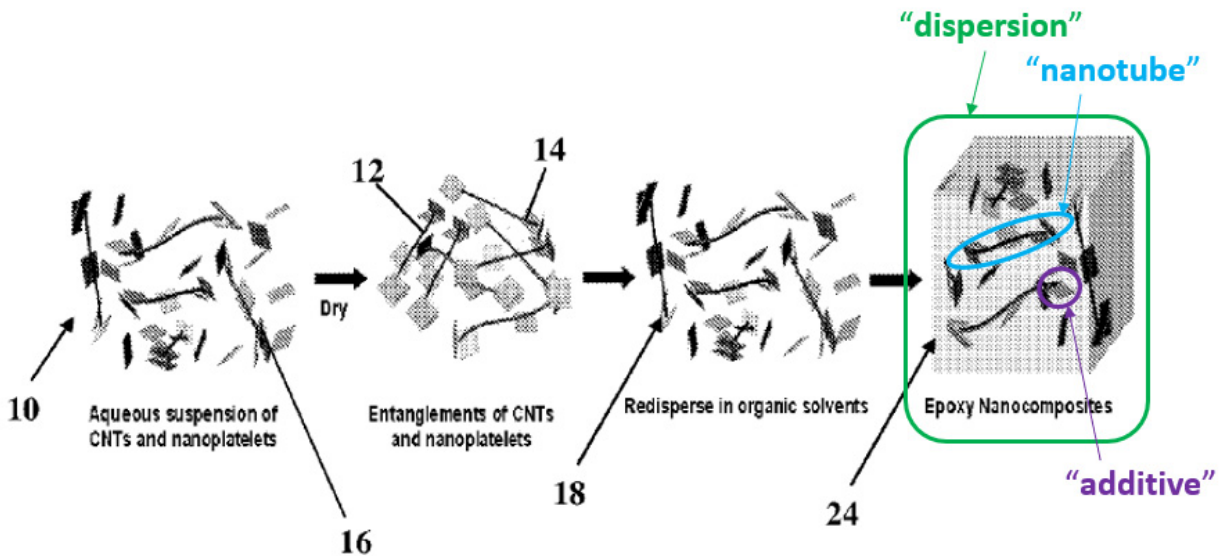
The medium (*e.g.*, the matrix of the nanocomposite) can be **an additive** to the nanocomposite dispersion in its precursor (*e.g.*, uncured) form. Sun describes that “the epoxy” that is mixed with the nanofiller “comprises ***an epoxy monomer***,” such as “diglycidyl ether of bisphenol-A.” LGES-1004, [0045]; *see* [0058], Abstract, claims 30-31, [0062], [0069], claims 1 and 13; *see also* [0052], claims 20 and 28. The precursor, *e.g.*, epoxy monomer, corresponds to **an additive**. LGES-1003, ¶68.

Alternatively/additionally, the medium (*e.g.*, the matrix of the nanocomposite) can be **an additive** to the nanocomposite dispersion in its cured form. Sun’s epoxy-nanofiller mixture is heated “to polymerize, crosslink, vulcanize, or otherwise cure ... the epoxy nanocomposite.” LGES-1004, [0046]; *see* [0058], [0010], [0062], [0069], Abstract, claims 1 and 13; *see also* [0052], claims 20 and 29. The cured matrix material (*e.g.*, epoxy) corresponds to **an additive**. LGES-1003, ¶69.

As a second example, Sun describes that “*a curing agent* is added to the epoxy and nanotubes.” LGES-1004, [0046]; *see* [0058]; *see also* [0052]. A POSITA would have recognized that the curing agent can correspond to **an additive**, *e.g.*, at least in the uncured nanocomposite. LGES-1003, ¶70.

As a third example, Sun describes that “the nanofiller is re-suspended in *acetone* prior to mixing in an epoxy.” LGES-1004, [0045]; *see* [0058]. In the uncured nanocomposite, *e.g.*, after addition of the epoxy and prior to “the solvent [being] removed from the epoxy nanocomposite” (*id.*, [0046]), a POSITA would have recognized that the acetone can correspond to **an additive**. LGES-1003, ¶71.

As a fourth example, a POSITA would have recognized that the nanoplatelets in Sun’s uncured or cured nanocomposite can correspond to **an additive**: “The nanotube-nanoplatelet association comprises a nanofiller 16” which “may be dispersed in a medium such as, but not limited to epoxy, plastic, or polymer, to form a nanocomposite 24.” LGES-1004, [0045]; *see* [0046], [0058], [0062], [0069], FIG. 1 (*infra*), FIG. 6, claims 3-4, 7-8, 13, 15-18, 20; LGES-1003, ¶72.



Except from Sun, FIG. 1 (annotated)

[1c]

The nanotubes in Sun's aqueous dispersion are oxidized, discrete carbon nanotubes (*see* [1a]) that **have an aspect ratio of 25 to 500**. Sun's "nanotubes have *an aspect ratio*, or length to diameter ratio, of *at least about 10*" or "*at least about 20*." LGES-1004, [0038]; *see* [0029]; LGES-1003, ¶¶73-75. For instance, Sun notes that "[t]he carbon nanotubes have a diameter of between about 1 nm and about 20 nm," and that "[t]he carbon nanotube length is at least about 100 nm." LGES-1004, [0038]. The lower limits of these ranges correspond to an **aspect ratio of 100** (*i.e.*, 100 nm length / 1 nm diameter). LGES-1003, ¶¶73-75.

The same nanotubes are present both in Sun's aqueous dispersion and in Sun's nanocomposite, as discussed in [1a]. *See* LGES-1004, [0044]-[0046]; LGES-1003, ¶73. Thus, the nanotubes in Sun's nanocomposite also are oxidized,

discrete carbon nanotubes (*see* [1a]) with an aspect ratio of at least 10 or at least 20, as described by Sun. *See* LGES-1004, [0038]; LGES-1003, ¶¶73-74.

These ranges of aspect ratios recited in element [1c] (“25 to 500”) overlaps with Sun’s disclosed range of aspect ratios (“at least about 10” or “at least about 20,” LGES-1004, [0038]), and at least one specific instance of Sun’s aspect ratio (100) falls within the claimed range. Moreover, the ’649 Patent provides no discussion, let alone any evidence, of unexpected results or criticality associated with nanotubes having an aspect ratio within the claimed range. LGES-1003, ¶¶74-75. Thus, Sun presents a *prima facie* case and renders obvious the recited range of aspect ratios. *See In re Peterson*, 315 F.3d 1325, 1329 (Fed. Cir. 2003) (“A *prima facie* case of obviousness typically exists when the ranges of a claimed composition overlap the ranges disclosed in the prior art”), citing *In re Geisler*, 116 F.3d 1465, 1469, 43 USPQ2d 1362, 1365 (Fed. Cir. 1997); *In re Woodruff*, 919 F.2d 1575, 1578, 16 USPQ2d 1934, 1936–37 (CCPA 1990); *In re Malagari*, 499 F.2d 1297, 1303, 182 USPQ 549, 553 (CCPA 1974); *In re Geisler*, 116 F.3d 1465, 1469–70 (Fed. Cir. 1997) (“When an applicant seeks to overcome a *prima facie* case of obviousness by showing improved performance in a range that is within or overlaps with a range disclosed in the prior art, the applicant must “show that the [claimed] range is *critical*, generally by showing that the claimed range achieves

unexpected results relative to the *1470 prior art range,” quoting *In re*

Woodruff, 919 F.2d 1575, 1578, 16 USPQ2d 1934, 1936 (Fed. Cir. 1990)).

[1d]

The nanotubes in Sun’s aqueous dispersion are **multiwall**: Sun’s aqueous dispersion includes “[o]xidized, suspended carbon nanotubes (CNTs) 12” such as “***multi-walled carbon nanotubes (MWNTs)***”).” LGES-1004, [0036]-[0038]; *see* [0054]-[0056], claims 13-14, claims 20 and 27, [0029]-[0030], [0068], [0006]; LGES-1003, ¶76.

The same nanotubes are present both in Sun’s aqueous dispersion and in Sun’s nanocomposite, as discussed in [1a]. *See* LGES-1004, [0044]-[0046]; LGES-1003, ¶77. Thus, the nanotubes in Sun’s nanocomposite also are **multiwall** nanotubes. LGES-1003, ¶77; *see* LGES-1004, [0069] (describing TEM images showing “epoxy nanocomposites ***containing MWNTs*** and exfoliated ZrP nanoplatelets”), [0058], [0069]; *see* [0022]-[0023], FIGS. 6A-6B; LGES-1003, ¶78.

[1e]

Sun’s aqueous dispersion renders obvious the claimed weight percentage of nanotubes

Sun’s aqueous dispersion has a “concentration of nanotubes” of “***at least 1 wt%***.” LGES-1004, [0043]; *see id.*, [0056]; LGES-1003, ¶¶79-80. The range of

weight percentages recited in element [1e] (“greater than zero to about 30% by weight”) overlaps this range of weight percentages described in Sun (e.g., “at least 1 wt%,” LGES-1004, [0043]). LGES-1003, ¶81. More, the ’649 Patent provides no discussion, let alone any evidence, of any unexpected results or criticality of the claimed range of weight percentages. LGES-1003, ¶82. Thus, given this overlap, Sun’s disclosure that its aqueous dispersion includes nanotubes in a concentration of at least 1 wt% renders obvious a dispersion including nanotubes in an amount ranging from greater than zero to 30% by weight. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

To the extent that fewer than all of the nanotubes in Sun’s dispersion are oxidized, discrete carbon nanotubes, they nevertheless constitute a portion of the “at least 1 wt %” of the entire population of nanotubes in Sun’s dispersion. LGES-1004, [0043]; LGES-1003, ¶83. Thus, the range of weight percentages recited in element [1e] (“greater than zero to about 30% by weight”) still overlaps with, and thus is rendered obvious by, the weight percentage of that oxidized, discrete subset of the nanotubes.

Sun’s nanocomposite renders obvious the claimed weight percentage of nanotubes

Sun’s nanocomposite has a “concentration of nanotubes in the epoxy [of] ***between about 0.01 wt% and about 50 wt%.***” LGES-1004, [0045]; *see id.*

(“Alternatively, the nanotube concentration is ***between about 0.05 wt% and about***

0.6 wt%; alternatively *between about 0.1 wt% and about 0.4 wt%*"); [0058] ("The redispersed MWNTs:ZrP ... were mixed with epoxy monomer ... to achieve a final [sic] *MWNT concentration of 0.2 and 0.4 wt%* in epoxy nanocomposites"), [0069], [0022]-[0023], FIG. 6; LGES-1003, ¶84. The range of weight percentages recited in element [1e] ("greater than zero to about 30% by weight") overlaps the range of weight percentages described in Sun (*e.g.*, between about 0.01 wt% and about 50 wt%; *see* LGES-1004, [0045]). And the '649 Patent provides no discussion, let alone any evidence, of unexpected results or criticality of the claimed range of weight percentages. LGES-1003, ¶85. Thus, given this overlap, Sun's disclosure that its nanocomposite includes nanotubes in a concentration of 0.01-50 wt% renders obvious a dispersion including nanotubes in an amount ranging from greater than zero to 30% by weight.

To the extent that only a subset of Sun's nanotubes are oxidized, discrete carbon nanotubes, those oxidized, discrete carbon nanotubes nevertheless constitute a portion of the 0.01-50 wt% concentration of the entire population of nanotubes in Sun's nanocomposite. *See* LGES-1004, [0045]; LGES-1003, ¶86. Thus, the range of weight percentages recited in element [1e] ("greater than zero to about 30% by weight") still overlaps with, and thus is rendered obvious by, the weight percentage of that oxidized, discrete subset of the nanotubes.

(ii) **Claim 2**

As discussed in [1a], a POSITA would have understood or found obvious that the nanotubes in Sun's dispersion (*e.g.*, in the aqueous dispersion or in the nanocomposite) are **discrete**, *e.g.*, based on Sun's description of the oxidation of the nanotubes in "a mixture of sulfuric acid and nitric acid." LGES-1004, [0039]; *see* [0054]. LGES-1003, ¶87. Oxidation of carbon nanotubes under these conditions can result in surface functionalization with species such as carboxylic acid or hydroxyl groups, which causes the nanotubes to be individually separated, *e.g.*, discrete. *See* LGES-1014, 821-822; LGES-1015, 4186-4187; LGES-1007, [0027]-[0028]; LGES-1016, 7:22-28, 13:40-45; LGES-1003, ¶87. A POSITA would have found it obvious that given Sun's functionalization treatment, substantially all of the nanotubes are functionalized such that they are discrete, *e.g.*, **at least 70% by weight of the nanotubes are discrete**.⁵ LGES-1003, ¶88.

Alternatively/additionally, the particular weight percent of nanotubes that are discrete in a given composition is a straightforward design choice. LGES-

⁵ Petitioner has applied art that discloses features that are consistent with features Patent Owner contends in its Infringement Contentions to be covered by claim 2, and without conceding agreement to Patent Owner's interpretation of this claim. *See* LGES-1050.

1003, ¶88. A POSITA implementing a dispersion including nanotubes would have considered incorporation of various weight percentages of discrete nanotubes, and indeed was constrained to a limited number of options, *i.e.*, ranging between fixed ends of between 0 and 100%. *Id.* Moreover, the specific “70 percent” recited in claim 2 presents no unexpected results or solution. *See In re Kuhle*, 526 F.2d 553, 555 (CCPA 1975) (use of claimed feature solves no stated problem and presents no unexpected result and “would be an obvious matter of design choice within the skill of the art”); *In re Chu*, 66 F.3d 292, 298-99 (Fed. Cir. 1995) (“design choice” is appropriate where the applicant fails to set forth any reasons why the differences between the claimed invention and the prior art would result in a different function).

(iii) Claim 3

As discussed in [1a], a POSITA would have understood or found obvious that the nanotubes in Sun’s dispersion are **discrete**, *e.g.*, that they are generally individual, separated nanotubes. A POSITA would have understood or found obvious that nanotubes that are generally individual and separated are not aggregated into a clump, and thus are **free flowing particles**, *e.g.*, in that a given nanotube can flow freely relative to another nanotube in the dispersion. LGES-1003, ¶89.

(iv) **Claim 4**

Sun's nanotubes are oxidized in "a mixture of sulfuric acid and nitric acid," *e.g.*, where "the nitric acid to sulfuric acid ratio is approximately 3:1." LGES-1004, [0039]; *see* [0054]. Oxidation of carbon nanotubes under these conditions is well-known to result in functionalization of the nanotube surfaces with, *e.g.*, carboxylic acid groups and hydroxyl groups. *See* LGES-1020, 8:54-58 ("functional groups such as carboxylic acid and hydroxyl groups were introduced on the surface of CNT upon treatment with concentrated nitric acid and concentrated sulfuric acid in the ratio of 1:3"); LGES-1019, [0062], [0080]; LGES-1016, 7:22-28; LGES-1021, [0023]; LGES-1014, 821-822; LGES-1003, ¶¶90-92. In view of this general knowledge and based on Sun's described oxidation process, a POSITA would have understood or found obvious that Sun's **oxidized, discrete nanotubes** (*see* [1a]) **comprise a carboxylic acid oxidation species**. LGES-1003, ¶¶90-94.

(v) **Claim 5**

As discussed in [4], a POSITA would have understood or found obvious that Sun's **oxidized, discrete nanotubes** (*see* [1a]) **comprise a hydroxyl species**. *See* LGES-1004, [0039], [0054]; LGES-1019, [0080]; LGES-1020, 8:54-58; LGES-1021, [0023]; LGES-1003, ¶95.

(vi) Claim 6

Sun's aqueous dispersion has a "concentration of nanotubes" of "*at least 1 wt%*," such that it would have been obvious that the oxidized, discrete carbon nanotubes (*see* [1a]) are present in Sun's aqueous dispersion **in the range of 15% to about 25% by weight**. LGS-1004, [0043]; LGES-1003, ¶96.

Alternatively/additionally, Sun's nanocomposite has a "concentration of nanotubes in the epoxy [of] *between about 0.01 wt% and about 50 wt%*," *e.g.*, the oxidized, discrete carbon nanotubes (*see* [1a]) are present in Sun's nanocomposite **in the range of 15% to about 25% by weight**. LGES-1004, [0045]; LGES-1003, ¶97.

The range of weight percentages recited in claim 6 (15% to about 25% by weight) overlaps and falls within the ranges of weight percentages described for both Sun's aqueous dispersion (*e.g.*, at least 1 wt%; *see* LGS-1004, [0043]) and for Sun's nanocomposite (*e.g.*, between about 0.01 wt% and about 50 wt%; *see id.*, [0045]). And the '649 Patent provides no discussion, let alone any evidence, of unexpected results or criticality of the claimed range of weight percentages. LGES-1003, ¶98. Thus, claim 6 is obvious in view of either Sun's aqueous dispersion or Sun's nanocomposite. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

(vii) **Claim 7**

Sun's aqueous dispersion has a "concentration of nanotubes" of "***at least 1 wt%***," such that it would have been obvious that the oxidized, discrete carbon nanotubes (*see* [1a]) are present in Sun's aqueous dispersion **in the range of 18% to about 22% by weight**. LGES-1004, [0043]; LGES-1003, ¶99.

Alternatively/additionally, Sun's nanocomposite has a "concentration of nanotubes in the epoxy [of] ***between about 0.01 wt% and about 50 wt%***," *e.g.*, the oxidized, discrete carbon nanotubes (*see* [1a]) are present in Sun's nanocomposite **in the range of 18% to about 22% by weight**. LGES-1004, [0045]; LGES-1003, ¶100.

The range of weight percentages recited in claim 7 (18% to about 22% by weight) overlaps and falls within the ranges of weight percentages described for both Sun's aqueous dispersion (*e.g.*, at least 1 wt%; *see* LGES-1004, [0043]) and for Sun's nanocomposite (*e.g.*, between about 0.01 wt% and about 50 wt%; *see id.*, [0045]). And the '649 Patent provides no discussion, let alone any evidence, of unexpected results or criticality of the claimed range of weight percentages. LGES-1003, ¶101. Thus, claim 7 is obvious in view of either Sun's aqueous dispersion or Sun's nanocomposite. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

(viii) Claim 11

In Sun's aqueous dispersion, the additive is the solvent in the dispersion (*e.g.*, water). *See* [1b]; *see* LGES-1004, [0036], [0042]-[0043], [0056], [0068], claims 13 and 20. That is, **the additive is a solvent**, *e.g.*, water. LGES-1003, ¶102.

Alternatively/additionally, in Sun's uncured epoxy nanocomposite, **the additive is a solvent**, *e.g.*, acetone. *See* [1b]; *see* LGES-1004, [0045], [0058]; LGES-1003, ¶103.

(ix) Claim 13

As discussed in [1b], in Sun's nanocomposite, the additive is the uncured matrix precursor, such as "***an epoxy monomer***," *e.g.*, "diglycidyl ether of bisphenol-A," which is heated in the presence of a curing agent to form an "epoxy nanocomposite." LGES-1004, [0045]-[0046]; *see* [0058], claims 19 and 28; *see also* [0052]. This epoxy monomer includes **a reactive species capable of creating a thermoset polymer**, *e.g.*, the reactive groups of the epoxy precursor. LGES-1003, ¶¶104-105. Specifically, Sun's epoxy monomers include reactive species (*e.g.*, epoxides, of which diglycidyl ether of bisphenol-A is one example) that are capable of creating epoxy polymers through reaction with a curing agent. *See* LGES-1004, [0045]-[0046]; *see* [0058], claims 19 and 30; LGES-1024, [0057]-[0060]; LGES-1003, ¶¶104-105. Moreover, the epoxy polymers created from

these reactive species are *thermoset polymers*. See LGES-1004, [0045] (“an epoxy may comprise *any thermosetting polymer* that cures, crosslinks, and/or hardens when mixed with a catalyzing agent”); LGES-1003, ¶¶104-106.

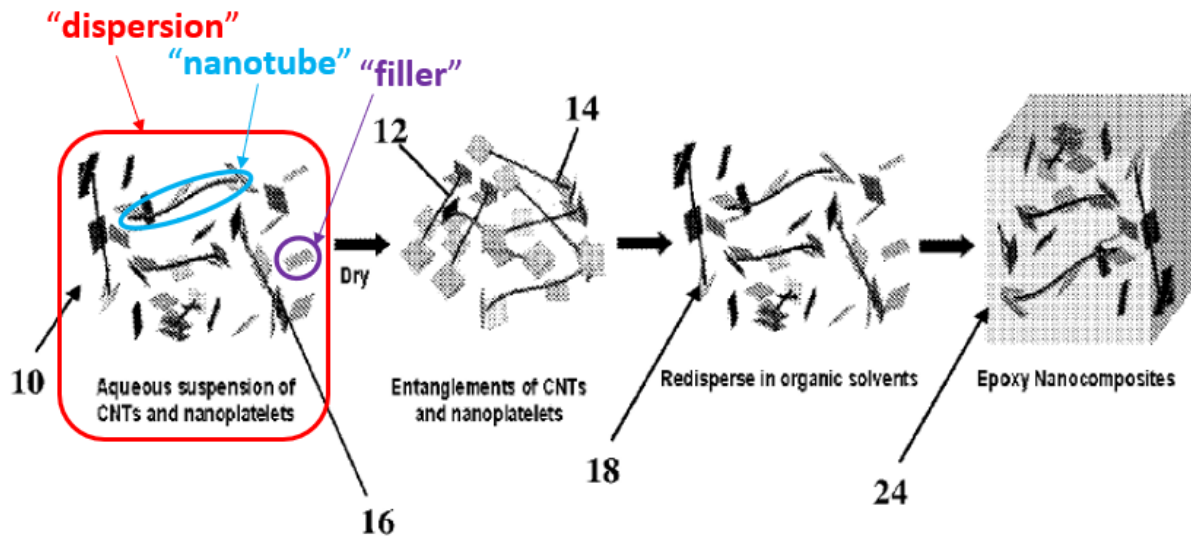
(x) **Claim 14**

Sun’s epoxy monomer additive includes a reactive species capable of creating a thermoset polymer, where **the thermoset polymer is an epoxy**. See [13]; LGES-1004, [0014], [0022]-[0023], [0027], [0045]-[0046], [0058], [0062], [0069], [0071]-[0072], claims 2, 10, 19, 30-31; *see also* [0052], claim 28; LGES-1003, ¶107.

(xi) **Claim 17**

Sun’s aqueous dispersion includes a filler

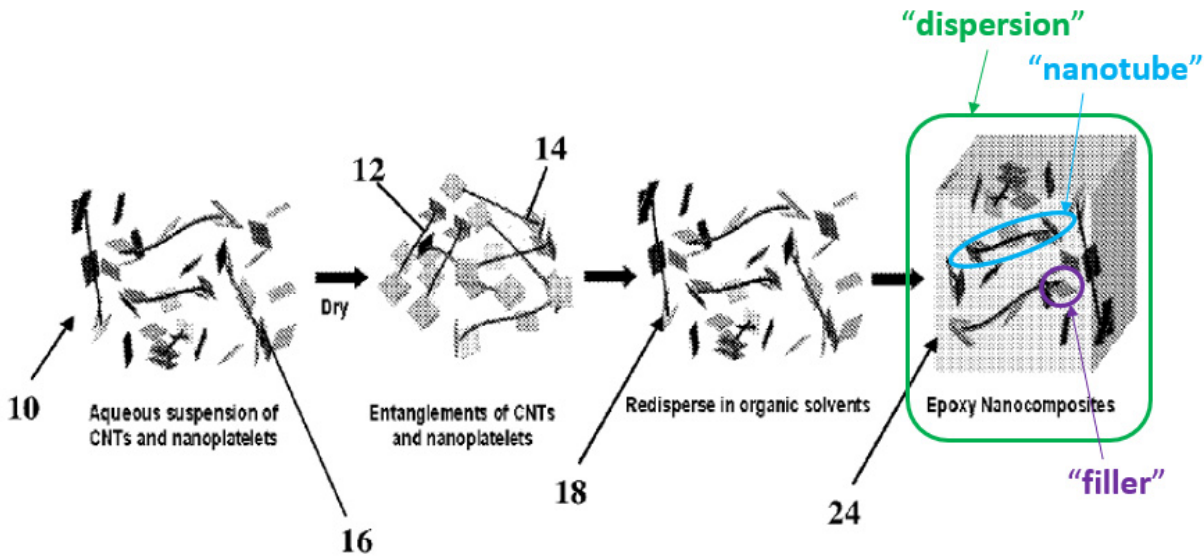
Sun’s aqueous dispersion (red in FIG. 1, *infra*) includes “*nanoplatelets* 14,” which “in solutions or solvents” with the nanotubes 12 “form a dispersion 10.” LGES-1004, [0036]. Sun’s nanoplatelets, purple, are **a filler** in the aqueous dispersion. LGES-1003, ¶108; *see* LGES-1004, [0043] (“the aqueous nanotube-nanoplatelet dispersion 10 is a substantially homogeneous solution of dispersed nanotubes 12 and associated *nanoplatelets* 14”), [0055]-[0056], [0068], claim 13, [0040]-[0042], [0044], [0047], claims 16-18, claim 20. For instance, Sun’s nanoplatelets can be considered a filler because their composition is consistent with that of the fillers in the ’649 Patent. See LGES-1004, [0041]; LGES-1001, 7:64-67; LGES-1003, ¶108.



Sun, FIG. 1 (annotated)

Sun's nanocomposite includes a filler

Sun's nanocomposite also includes nanoplatelets. Sun's nanoplatelets, purple in FIG. 1, *infra*, are a **filler** in the nanocomposite. See LGES-1004, [0045], [0046] ("The nanofiller and epoxy mixture comprises a nanocomposite 24"), [0058], [0062], [0069] ("FIG. 6 shows the TEM images of epoxy nanocomposites containing MWNTs and exfoliated ZrP nanoplatelets"), FIG. 6; claims 3-4, 7-8, 13, 15-18; LGES-1003, ¶109.



Sun, FIG. 1 (annotated)

(xii) Claim 18

Sun's nanoplatelets (*e.g.*, the filler; *see* [17]) **have at least one dimension less than about 20 microns**. Specifically, Sun's nanoplatelets "*have a diameter range from about 10 nm to about 20,000 nm*", and preferably between about 100 nm and 1000 nm." LGES-1004, [0040]; *see* FIG. 2B, [0055]-[0056]; *see* [0016]-[0017]; LGES-1003, ¶¶110-1106.

(xiii) Claim 19

Sun's nanoplatelets (*e.g.*, the filler; *see* [17]) are **graphite**: "The nanoplatelets comprise any suitable material ... such as ... **graphite**." LGES-1004, [0041]; *see* claims 4 and 15; LGES-1003, ¶117.

B. [GROUND 1B] – CLAIM 8 IS OBVIOUS OVER SUN AND BURETEA

The sections below provide an introduction to Buretea and the Sun-Buretea combination.⁶

1. Buretea describes nanotube-resin composites including plasticizers

Buretea describes “a nanowire-material composite.” LGES-1005, Abstract. The nanowires in Buretea’s composite can be “any elongated conductive or semiconductive material” having dimensions in a specified range, *e.g.*, “carbon nanotubes.” *Id.*, 7:16-60. Buretea’s composite “optionally comprises additives,” such as “a plasticizer,” “to modify the properties of the material.” *Id.*, 15:64-16:20; LGES-1003, ¶¶118-120.

2. The Sun-Buretea combination

The Sun-Buretea nanocomposite is based on Sun’s nanocomposite, with the addition of a plasticizer based on Buretea. *See* LGES-1005, 15:64-66, 16:4-20; LGES-1004, [0045]-[0046]; LGES-1003, ¶¶121-122.

3. Reasons for the combination

A POSITA would have been motivated to incorporate a plasticizer into Sun’s nanocomposite. LGES-1003, ¶¶123-127.

⁶ Petitioner incorporates this discussion into Ground 1B.

First, a POSITA would have been motivated to pursue this implementation to “influence the morphology” of the combination nanocomposite or to “decrease the flexural modulus” of the nanocomposites, which would render the nanocomposites broadly useful. LGES-1005, 16:1-2; LGES-1003, ¶124.

Second, a POSITA would have been motivated to incorporate a plasticizer into Sun’s nanocomposite to “affect the melting temperature and glass transition temperature” of the nanocomposite, again making the nanocomposites relevant for various applications. LGES-1005, 16:1:4; LGES-1003, ¶¶125-126.

Third, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (plasticizer as an additive in a nanotube-containing nanocomposite) to a known structure (Sun’s nanocomposite) to yield predictable results (a nanotube-containing nanocomposite including plasticizer). LGES-1003, ¶127; *see KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007) (a supposed invention that “simply arranges old elements with each performing the same function it had been known to perform” is obvious).

A POSITA would have expected success in incorporating a plasticizer into Sun’s nanocomposite. LGES-1003, ¶¶128-131.

First, Buretea's materials system is similar to the materials system of Sun's nanocomposite, as explained by Dr. Guido. *See* LGES-1004, [0044]-[0046]; LGES-1005, 7:16-60, 15:28-62); LGES-1003, ¶129.

Second, the nanotubes in Buretea's and Sun's nanocomposites have similar dimensions. *See* LGES-1005, 7:17-28; LGES-1004, [0037]-[0038]; LGES-1003, ¶130.

Third, a POSITA would have expected success because the incorporation of plasticizers as additives into nanotube-containing resin composites was well-known. *See* LGES-1005, 15:66-16:20; LGES-1010, [0039]; LGES-1022, [0041]; LGES-1003, ¶131.

4. Analysis

(i) Claim 8

The Sun-Buretea nanocomposite includes **a polymeric plasticizer as an additive** based on Buretea. LGES-1005, 15:64-66 (“The nanowire-material composite ... comprises additives to modify the properties of the material 608. One example of an additive is *a plasticizer*”); LGES-1003, ¶132. Buretea's “plasticizer” additive in the Sun-Buretea nanocomposite is **a polymeric plasticizer**, *e.g.*, because it is an additive to a polymer matrix (*e.g.*, the matrix material, such as epoxy resin, of Sun's nanocomposite; *see* LGES-1004, [0045]-[0046]), consistent with its use in Buretea's composite. LGES-1005, 15:67-16:1

(“Plasticizer is used herein to mean any material that can decrease the flexural modulus of a polymer”), 15:20-66; LGES-1003, ¶132. Buretea’s “plasticizer” additive is alternatively/additionally a **polymeric plasticizer** because the plasticizer itself is a polymer. LGES-1003, ¶133. For instance, Buretea identifies polymers, such as “oligomers and small molecular weight *polymers* ..., highly-branched *polymers* and *dendrimers*,” as “[e]xamples of plasticizers.” LGES-1005, 16:4-20; LGES-1003, ¶133.

Alternatively/additionally, the Sun-Buretea nanocomposite includes **glycols** and **polyethers** as an **additive** based on Buretea. LGES-1005, 16:4-20; LGES-1003, ¶¶134-135. Buretea identifies “alcohols such as glycerol, *ethylene glycol*, *diethylene glycol*, *triethylene glycol*, [and] oligomers of *ethylene glycol*” and “ethers such as oligomers of *polyethylene glycol*, including PEG-500, PEG 1000 and PEG-2000” as “[e]xamples of plasticizers.” LGES-1005, 16:4-20. At least some of these example plasticizers are glycols: ethylene glycol, diethylene glycol, triethylene glycol, oligomers of ethylene glycol, and oligomers of polyethylene glycol. LGES-1003, ¶¶134-135. When the plasticizer additive in the combination is one of these glycols, the Sun-Buretea nanocomposite includes **glycols** as an **additive**. Polyethylene glycol is also a **polyether**. LGES-1003, ¶¶134-135. When the plasticizer additive in the combination is polyethylene glycol, the Sun-Buretea nanocomposite includes **polyethers** as an additive. *Id.*

**C. [GROUND 1C] – CLAIMS 9-10, 15, AND 21-23 ARE OBVIOUS
OVER SUN AND KAJI**

The sections below provide an introduction to Kaji and the Sun-Kaji combination.⁷

1. Kaji describes nanotube-resin composites including carnauba wax and silicone oil additives

Kaji describes a “crystalline resin cured product which shows high thermal conductivity, low thermal expansion, high heat resistance, low moisture absorption, and good gas barrier properties.” LGES-1006, [0001]. Kaji’s resin product is “produced by combining a resin with a filler or base material,” such as “carbon nanotubes.” *Id.*, [0024], [0068]. The crystalline resin cured product can have a “three-dimensional structure,” *e.g.*, a crosslinked structure. *Id.*, [0059]; LGES-1003, ¶¶136-138.

Kaji’s resin composite material can include various additives, including “mold release agents such as carnauba wax and ester wax ..., stress-lowering agents such as silicone oils, and lubricants.” LGES-1006, [0067]; LGES-1003, ¶139.

⁷ Petitioner incorporates this discussion into Grounds 1C-1D.

2. The Sun-Kaji combination

In the Sun-Kaji combination, based on Kaji, silicone oil or a wax such as carnauba wax is incorporated as an additive in Sun's nanocomposite. *See* LGES-1006, [0067]; LGES-1004, [0045]-[0046]; LGES-1003, ¶140.

3. Reasons for the combination

Reasons for incorporation of carnauba wax

A POSITA would have been motivated to incorporate a wax, such as carnauba wax, into Sun's nanocomposite. LGES-1003, ¶¶141-144.

First, a POSITA would have been motivated to pursue this implementation so that the combination nanocomposite would possess the “mold release” capabilities of carnauba wax, which is advantageous for processing and structural integrity of the nanocomposite. LGES-1006, [0067]; LGES-1003, ¶142. (citing LGES-1025, 5:46-52); LGES-1003, ¶142.

Second, a POSITA would have been motivated to pursue this implementation because carnauba wax provides desirable anti-moisture properties. *See* LGES-1011, [0050]-[0051]; LGES-1003, ¶143.

Third, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (carnauba wax in a nanotube-based nanocomposite) to a known structure (Sun's nanocomposite) to yield predictable results (a nanotube-based nanocomposite including carnauba wax). LGES-1003, ¶144; *see KSR*, 550 U.S. at 417.

Reasons for incorporation of silicone oil

A POSITA would have been motivated to incorporate silicone oil into Sun's nanocomposite. LGES-1003, ¶¶145-151.

First, a POSITA would have been motivated to pursue this implementation to obtain the “stress-lowering” properties of silicone oil in the combination nanocomposite. LGES-1006, [0067]; *see* LGES-1026, 41:18-21; LGES-1027, [0161]; LGES-1003, ¶146.

Second, a POSITA would have been motivated to pursue this implementation because silicone oils are useful as mold release agents, providing advantages in processing complexity and time. *See* LGES-1042, 32; LGES-1003, ¶¶147-150.

Third, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (silicone oil in a nanotube-based nanocomposite) to a known structure (Sun's nanocomposite) to yield predictable results (a nanotube-based nanocomposite including silicone oil). LGES-1003, ¶151; *see KSR*, 550 U.S. at 417.

Expectation of success in incorporating silicone oil or wax into the combination nanocomposite

A POSITA would have expected success in incorporating silicone oil and/or carnauba wax into Sun's nanocomposite. LGES-1003, ¶¶152-155.

First, Kaji's materials system is similar to the materials system of Sun's nanocomposite. *See* LGES-1004, [0044]-[0046], [0068]; LGES-1006, [0024], [0068]; LGES-1003, ¶153.

Second, the weight percentage of filler (*e.g.*, carbon nanotubes) in Kaji's composite is consistent with the weight percentage of nanotubes in Sun's nanocomposite. *See* LGES-106, [0024]; LGES-1004, [0045]; LGES-1003, ¶154.

Third, a POSITA would have expected success because the incorporation of silicone oil and carnauba wax into nanotube-containing resin composites was well-known. *See* LGES-1006, [0067]; LGES-1012, [0091]; LGES-1003, ¶155.

4. Analysis

(i) Claim 9

The Sun-Kaji nanocomposite includes “stress-lowering agents such as *silicone oils*” as an additive, based on Kaji. LGES-1006, [0067]; LGES-1003, ¶156. Silicone oil is **a process oil**.⁸ LGES-1003, ¶156.

(ii) Claim 10

In the Sun-Kaji nanocomposite, the process oil is a silicone oil, *i.e.*, a **silicone**. *See* [9]; LGES-1006, [0067]; LGES-1003, ¶157.

⁸ The '649 Patent identifies silicone as an example of a process oil. *See* LGES-1001, 7:41-46, claim 10; LGES-1003, ¶156.

(iii) **Claim 15**

The Sun-Kaji nanocomposite includes “mold release agents such as *carnauba wax and ester wax*” as an additive, based on Kaji. LGES-1006, [0067]; LGES-1003, ¶158. Carnauba wax is **a natural wax**. *See* LGES-1011, [0051] (identifying “carnauba wax” as “a *plant-based* antimoisture agent”); LGES-1028, [0107] (“natural waxes such as carnauba wax”); LGES-1003, ¶158.

(iv) **Claim 21**

In the Sun-Kaji combination, Sun describes that the nanocomposite includes a curing agent: “*a curing agent* is added to the epoxy and nanotubes, and heated to polymerize, crosslink, vulcanize, or otherwise cure ... the epoxy nanocomposite.” LGES-1004, [0046]; *see* [0058]; *see also* [0052]. The curing agent is **a crosslinking agent** in that it enables crosslinking in the epoxy to thus form a crosslinked epoxy polymer matrix. LGES-1003, ¶159.

(v) **Claim 22**

In the Sun-Kaji nanocomposite, the additive includes “*carnauba wax*,” based on Kaji. LGES-1006, [0067]; *see* [15]; LGES-1003, ¶160. Carnauba wax is **a natural wax** that is **plant derived**. *See* LGES-1011, [0051]; LGES-1028, [0107]; LGES-1003, ¶160.

(vi) **Claim 23**

See [21]; LGES-1003, ¶161.

**D. [GROUND 1D] – CLAIMS 16 AND 20 ARE OBVIOUS OVER
SUN, KAJI, AND MATSUSHITA**

The sections below provide an introduction to Matsushita and the Sun-Kaji-Matsushita combination.⁹

1. Matsushita describes nanocomposites including fluororubber

Matsushita describes a “resin composite material” including a “fibrous carbon-based material insulator ... and a resin.” LGES-1013, [0072]. The “fibrous carbon-based material” is, *e.g.*, “carbon nanotubes,” such as “multi-walled carbon nanotubes.” *Id.*, [0009], [0021]. Matsushita describes various resin compositions, identifying “thermosetting resins such as epoxy resin” as suitable examples. *Id.*, [0073]. Additionally, the resin can include “[c]rosslinked rubbers such as ... fluororubber.” *Id.*, [0073]; LGES-1003, ¶¶162-163.

2. Sun-Kaji-Matsushita provides a nanocomposite including a fluororubber

In the Sun-Kaji-Matsushita combination, based on Matsushita, a fluororubber is incorporated into the Sun-Kaji nanocomposite. *See* LGES-1013, [0073]; LGES-1004, [0045]-[0046]; LGES-1003, ¶164. For instance, the resin matrix of the Sun-Kaji nanocomposite is modified to be “a composite of” “fluororubber” with the resin. LGES-1013, [0073]; LGES-1003, ¶164.

⁹ Petitioner incorporates this discussion into Ground 1D.

3. Reasons for the combination

A POSITA would have been motivated to incorporate a fluororubber into the Sun-Kaji nanocomposite. LGES-1003, ¶¶165-168.

First, a POSITA would have been motivated to pursue this implementation because of the chemical and corrosion resistance provided by fluoroelastomers (*e.g.*, fluororubbers). *See* LGES-1029, 5:39-41; LGES-1030, 14:64-15:2; LGES-1003, ¶¶166-167.

Second, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (fluororubber in a resin matrix nanocomposite) to a known structure (the Sun-Kaji nanocomposite) to yield predictable results (a nanocomposite including fluororubber). LGES-1003, ¶168; *see KSR*, 550 U.S. at 417.

A POSITA would have expected success in incorporating a fluororubber into the Sun-Kaji nanocomposite. LGES-1003, ¶¶169-173.

First, Matsushita's materials system is similar to the materials systems of Sun and Kaji. Matsushita's nanocomposite includes carbon nanotubes in a polymer matrix, consistent with the composition of the Sun-Kaji nanocomposite. *See* LGES-1013, [0009], [0021], [0072]-[0073]; LGES-1004, [0044]-[0046], [0068]; LGES-1006, [0024], [0059], [0068]; LGES-1003, ¶170.

Second, Matsushita’s nanotubes are similar to the nanotubes in the Sun-Kaji nanocomposite. *See* LGES-1013, [0022]-[0023]; LGES-1004, [0037]-[0038].; LGES-1003, ¶171.

Third, Matsushita’s resin nanocomposite including fluororubber can be used with additives including “mold release agents.” LGES-1013, [0074]. A mold release agent—carnauba wax—is present in the Sun-Kaji nanocomposite. *See* LGES-1006, [0067]; *see* [15]. A POSITA would have expected success in introducing a fluororubber into the Sun-Kaji nanocomposite given Matsushita’s confirmation that fluororubber is compatible with mold release agents. LGES-1003, ¶172.

Fourth, a POSITA would have expected success because resin composites including fluororubber were well-known. LGES-1013, [0073]; LGES-1022, [0035]; LGES-1049, 6:63-65, LGES-1048, 305-306 LGES-1003, ¶173.

4. Analysis

(i) Claim 16

The Sun-Kaji-Matsushita nanocomposite includes “[c]rosslinked rubbers such as ... fluororubber,” based on Matsushita. LGES-1013, [0073]; LGES-1003, ¶174. Rubber is an elastomer, and thus the fluororubber in the combination is a **fluoroelastomer**. LGES-1003, ¶175.

(ii) Claim 20

[20pre]-[20a]

See [1pre]-[1a]; LGES-1003, ¶176.

[20b]-[20c]

See [15]-[16]; LGES-1003, ¶¶177-178.

[20d]

See [1c]-[1e]; LGES-1003, ¶179.

**E. [GROUND 2A] – CLAIMS 1-8, 11-15, 17-19, AND 21 ARE
OBVIOUS OVER FARRUGIA AND NARAYAN**

The sections below provide an introduction to Farrugia, Narayan, and their combination.¹⁰

**1. Farrugia describes toners including electrically
conductive nanotube/polymer composites**

Farrugia describes “a toner comprising a resin comprising a polymerized mixture,” where “the polymerized mixture is a composite comprising carbon nanotubes and a polymer.” LGES-1007, [0019]. “Toners comprising carbon nanotube/polymer resins exhibit enhanced mechanical, chemical, thermal and electrical properties.” *Id.*, [0018]. For instance, “when the carbon nanotube/polymer composite comprises carbon nanotubes from about 2% to about

¹⁰ Petitioner incorporates this discussion into Grounds 2A-2B.

20% by weight of the composite, the toner exhibits increased conductivity, and thus is suitable for conductive developing methods.” *Id.* Farrugia attributes this enhanced electrical conductivity to the aspect ratio of nanotubes: “Because carbon nanotubes have a high aspect ratio, only small amounts of carbon nanotubes need to be present in a toner in order to achieve the same conductivity as compared to conventional conductive additives.” *Id.*; LGES-1003, ¶¶180-181.

To make Farrugia’s nanotube/polymer composite, the nanotubes are “functionalized” and “combined with a molar excess of a first monomer,” and the nanotubes “reacted with the first monomer to covalently attach the functionality moieties on the carbon nanotubes to the first monomer.” LGES-1007, [0028], [0040]-[0042]; *see* [0020]. “The functionalized carbon nanotubes covalently attached to a first monomer and any excess unreacted first monomer may be polymerized with a second monomer ... to form a polymer matrix in which the carbon nanotubes are dispersed.” *Id.*, [0045]; *see* [0020], [0048]-[0052]; LGES-1003, ¶¶182-185.

The carbon nanotube/polymer composite is “incorporated into a toner,” which also may include various additives to provide desired properties to the toner. *Id.*, [0054]; *see* [0068]-[0084]; LGES-1003, ¶186.

2. Narayan describes electrically conductive carbon nanotube/polymer compositions

Narayan describes “polymeric foams and elastomers comprising carbon nanotubes.” LGES-1008, Abstract. The amount and characteristics of the carbon nanotubes are “selected so as to provide electrical conductivity” to the composite. *Id.*, [0008]. For instance, the carbon nanotubes have “diameters of about 0.5 to about 2000 nm, with aspect ratios greater than or equal to about 5,” are “suitable ... for imparting electric conductivity to the polymeric foams and elastomers.” *Id.*, [0014]; LGES-1003, ¶¶187-188.

3. The Farrugia-Narayan combination

In the Farrugia-Narayan combination, the carbon nanotubes in Farrugia’s nanotube/polymer composite, and in the toner incorporating that composite, have “aspect ratios greater than or equal to about 5,” “greater than or equal to about 10,” or “greater than or equal to about 100,” based on Narayan. LGES-1008, [0014]; LGES-1003, ¶¶189-190.

As demonstrated *infra*, the dispersion of the Challenged Claims is rendered obvious by any of (1) the unpolymerized mixture of functionalized nanotubes and monomers, (2) the polymerized nanotube/polymer composite, or (3) the toner incorporating this composite. LGES-1003, ¶191.

4. Reasons for the combination

A POSITA would have been motivated to use nanotubes having aspect ratios such as those described by Narayan in the combination nanotube/polymer composites and toners. LGES-1003, ¶¶192-196.

First, a POSITA would have been motivated to pursue this implementation to obtain a “toner [that] exhibits increased conductivity,” which is a design objective for Farrugia’s toner. LGES-1007, [0018]; *see* [0009]-[0012]; LGES-1003, ¶193. Bearing in mind Farrugia’s indication that the “high aspect ratio” of nanotubes is relevant to achieving “increased conductivity” in a toner including its nanotube/polymer composite, a POSITA would have looked to Narayan for guidance as to the aspect ratio appropriate for this objective. LGES-1007, [0018]; LGES-1003, ¶¶194-195. For instance, a POSITA would have recognized that Narayan’s teachings that carbon nanotubes with “aspect ratios greater than or equal to about 5” are “suitable for imparting electrical conductivity” to nanotube/foam compositions, and would have implemented the nanotubes in Farrugia’s nanotube/polymer composite according to Narayan’s guidance. LGES-1008, [0014]; LGES-1003, ¶195.

Second, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (nanotubes having aspect ratios greater than or equal to about 5, 10, or 100) to a

known structure (Farrugia's nanotube/polymer composite) to yield predictable results (a nanotube/polymer composite including nanotubes sized as taught by Narayan). LGES-1003, ¶196; *see KSR*, 550 U.S. at 417.

A POSITA would have expected success in using nanotubes having aspect ratios such as those described by Narayan in the Farrugia-Narayan combination. LGES-1003, ¶¶197-201.

First, the composition of Narayan's polymer foam ("a wide variety of thermoplastic resins, blends of thermoplastic resins, or thermosetting resins" such as "polyurethanes" or "polyesters," among others (LGES-1008, [0009]-[0011])) is consistent with the composition of Farrugia's polymer matrix (*e.g.*, "polyesters and polyurethanes," among others (LGES-1007, [0048]-[0052])). A POSITA would have expected success in using nanotubes dimensioned based on Narayan in a nanotube/polymer matrix such as Farrugia's given that Narayan demonstrates that such nanotubes can be used with polymer compositions similar to those described by Farrugia. LGES-1003, ¶198.

Second, the weight percentage of nanotubes in Narayan's nanotube/polymer composition ("about 0.0001 to about 50 weight percent," LGES-1008, [0016]) is consistent with the weight percentage of nanotubes in Farrugia's nanocomposite ("from about 2% to about 20% by weight," LGES-1007, [0018]). A POSITA would have expected success in introducing nanotubes dimensioned based on

Narayan into in a nanotube/polymer matrix such as Farrugia's given that Narayan demonstrates that such nanotubes can be used in the range of weight percentages contemplated by Farrugia. LGES-1003, ¶199.

Third, a POSITA would have expected success because both Narayan and Farrugia describe using nanotubes in a polymer to increase electrical conductivity. *See* LGES-1007, [0009]-[0012], [0018]; LGES-1008, [0008]; LGES-1003, ¶200. Although Farrugia provides guidance on the concentration of nanotubes useful for achieving this objective, and indicates that nanotubes are suitable because of their "high aspect ratio," Farrugia does not identify specific values of the aspect ratio. *See* LGES-1007, [0018]; LGES-1003, ¶200. Narayan, though, does provide such guidance: "mixing nanotubes with the polymer... may achieve excellent conductivity at low loading levels, because of the preservation of nanotube aspect ratio," and identifies "[s]uitable carbon nanotubes for imparting electrical conductivity" as having "diameters of about 0.5 to about 2000 nm, with aspect ratios greater than or equal to about 5." LGES-1008, [0014], [0025]. A POSITA would have expected success in relying on Narayan's teachings given the overlap in objective (increasing electrical conductivity) and given Narayan's specific implementation of nanotubes already suggested by Farrugia. *See* LGES-1008, [0014], [0025]; LGES-1007, [0018]; LGES-1003, ¶200.

Fourth, a POSITA would have expected success because the use of nanotubes having aspect ratios such as those described by Narayan in nanotube/polymer composites was well-known. *See* LGES-1008, [0014], [0025]; LGES-1046, [0230]; LGES-1003, ¶201.

5. Analysis

(i) Claim 1

[1pre]

To the extent the preamble is deemed to be limiting, Farrugia-Narayan renders it obvious. LGES-1003, ¶¶202-208.

In the combination, Farrugia's nanotube/polymer composite is a dispersion

In the Farrugia-Narayan combination, Farrugia's carbon nanotube/polymer composite is **a dispersion** at least because it includes nanotubes dispersed in a polymer matrix. LGES-1003, ¶203. Specifically, the composite is “a polymer matrix comprising *carbon nanotubes dispersed in a polymer matrix*.” LGES-1007, Abstract; *see* [0020] (“The chemical moiety on the carbon nanotubes generally covalently attach to a suitable monomer. The monomers then polymerize ... thereby forming *carbon nanotubes dispersed in a polymer matrix*.”), [0027]-[0028], [0045], [0001], claims 1 and 16; LGES-1003, ¶203.

Alternatively/additionally, the unpolymerized mixture that is cured to form the nanotube/polymer composite is **a dispersion**. LGES-1003, ¶204. Specifically, Farrugia describes that to make the nanotube/polymer composite, “functionalized

carbon nanotubes covalently attached to a first monomer and any excess unreacted first monomer may be polymerized with a second monomer ... to form a polymer matrix in which the carbon nanotubes are dispersed.” *Id.*, [0045]; *see* [0020], [0041]. Prior to the polymerization, the functionalized nanotubes, excess first monomer, and second monomer are mixed together and heated. *See* LGES-1007, [0093], [0096]; LGES-1003, ¶¶204-205. The heated, unpolymerized mixture of carbon nanotubes and monomers is **a dispersion**, *e.g.*, at least because the nanotubes are dispersed in a molten mixture of monomer.¹¹ LGES-1003, ¶206.

In the combination, Farrugia’s toner is a dispersion

In the Farrugia-Narayan combination, Farrugia’s “carbon nanotube/polymer composite [is] incorporated into a toner.” LGES-1007, [0054]; *see* [0018] (“toners comprising carbon nanotube/polymer composite resins”), Abstract, [0001], [0019]-[0020]; claims 1, 11, 16; LGES-1003, ¶¶207-208. The combination toner is alternatively/additionally **a dispersion**, at least because it includes the

¹¹ As explained by Dr. Gido, the monomers may start reacting before the second monomer is fully melted, such that the nanotubes are dispersed in a mixture of unreacted monomers and oligomers. For convenience, this mixture is referred to as the unpolymerized mixture. LGES-1003, ¶206.

nanotube/polymer composite, which is itself a dispersion, as discussed *supra*.

LGES-1003, ¶¶207-208.

[1a]

First, in the Farrugia-Narayan combination, Farrugia describes that the nanotubes in the dispersions (*e.g.*, the unpolymerized mixture, the nanotube/polymer composite, and the toner; *see* [1pre]) are **carbon nanotubes**. *See* LGES-1007, Abstract (“A toner comprising: a polymer matrix comprising **carbon nanotubes** dispersed in a polymer”), [0018] (“The present disclosure is directed to toners comprising **carbon nanotube/polymer composite resins**”), [0045], [0001], [0019]-[0020], [0024]-[0028], [0039]-[0042], [0053]-[0054], [0056]-[0057], [0088]-[0097], [0104]-[0107]; claims 1, 4-6, 8, 11, 16-18; LGES-1003, ¶¶209-210.

Second, in the combination, Farrugia describes that the carbon nanotubes in the dispersions are **oxidized**. For instance, Farrugia’s nanotubes are “functionalized” carbon nanotubes, where the “functionalized nanotubes can be directly prepared by ... **oxidation**.” LGES-1007, [0028]; *see* [0020], [0026], [0045] (“The **functionalized carbon nanotubes** covalently attached to a first monomer and any excess unreacted first monomer may be polymerized with a second monomer ... to form a polymer matrix in which the carbon nanotubes are dispersed.”), [0029]-[0039], [0041]-[0042], [0045], [0088]-[0097]; claims 8, 11.

That is, for instance, Farrugia's functionalized carbon nanotubes, in which the functionalization is carried out by oxidation, are **oxidized** carbon nanotubes.

LGES-1003, ¶¶211-214.

Third, in the Farrugia-Narayan combination, Farrugia describes or renders obvious that the nanotubes in the dispersions (*e.g.*, the unpolymerized mixture, the nanotube/polymer composite, and the toner; *see* [1pre]) are **discrete**, *e.g.*, to the extent this is interpreted as indicating that the nanotubes in the dispersion are generally individually distinct, *e.g.*, lacking direct association with other nanotubes along substantially the length of the nanotubes: “***Discrete nanotubes*** ... may be suitable for use according to the present disclosure.” LGES-1007, [0024]; LGES-1003, ¶¶215-216.

[1b]

The unpolymerized mixture includes an additive

In the unpolymerized mixture, a POSITA would have recognized the “second monomer” as corresponding to **an additive**. LGES-1007, [0045]; *see* [0093] (identifying 1,12-dodecanedioic acid as the second monomer, *e.g.*, an additive), [0096]; LGES-1003, ¶¶217-219. Farrugia provides numerous examples of second monomers (**additives**), listed in [0046]-[0047]. LGES-1003, ¶219.

Alternatively/additionally, Farrugia's unpolymerized mixture includes “excess unreacted first monomer.” LGES-1007, [0045]; *see* [0093], [0096]. A

POSITA would have recognized this excess first monomer as also corresponding to **an additive**. LGES-1003, ¶220. Farrugia provides numerous examples of first monomers (**additives**), listed in [0043]-[0044]. LGES-1003, ¶220.

The nanotube/polymer composite includes an additive

The combination nanotube/polymer composite is “a polymer matrix comprising carbon nanotubes dispersed in **a polymer**.” LGES-1007, Abstract; *see* [0001], [0018]-[0020], [0045], [0088], [0093]-[0097]; claims 1-6, 8, 10, 14, 16-18. A POSITA would have recognized the polymer in which the nanotubes are dispersed as corresponding to **an additive**. LGES-1003, ¶221. Specifically, Farrugia describes that “[t]he functionalized carbon nanotubes covalently attached to a first monomer and any excess unreacted first monomer may be polymerized with a second monomer ... to form a polymer matrix in which the carbon nanotubes are dispersed.” LGES-1007, [0045]. Farrugia provides numerous examples of the polymers (**additives**), listed in [0048]-[0052]. LGES-1003, ¶¶222-223.

The toner includes an additive

Because the combination toner contains the nanotube/polymer composite (*see* [1pre]), the toner includes the polymer matrix within which the nanotubes are dispersed. *See* LGES-1007, [0054]. A POSITA would have recognized this

polymer matrix as also corresponding to **an additive** to the toner. LGES-1003, ¶224.

Farrugia also describes additional examples that a POSITA would have recognized as corresponding to **additives** in the combination toner. *See* LGES-1007, [0054]; LGES-1003, ¶¶225-228.

A first example of an additive in the Farrugia-Narayan toner is a *wax*. *See* LGES-1007, Abstract (“A toner comprising: a polymer matrix comprising carbon nanotubes dispersed in a polymer ... and optionally one or more waxes”), [0071], [0019], [0055], [0057], claims 1 and 11; LGES-1003, ¶226.

A second example of an additive in the Farrugia-Narayan toner is a *surfactant*. *See* LGES-1007, [0072]-[0073] (listing “[e]xamples of nonionic surfactants” and “cationic surfactants” “that may be used in the toner”), [0055], [0074]-[0075]; LGES-1003, ¶227.

Additional examples: Farrugia also describes additional **additives** in the Farrugia-Narayan toner, including *clarifiers*, *tackifiers*, *plasticizers*, *adhesives*, *antioxidants*, and *charge-controlling agents*. *See* LGES-1007, [0076]-[0083]. Other examples of additives include “a fluidization agent ...; lubricants ...; silica; a spacing agent; a dryer; a dispersant; a humectant; a stabilizer; a thickening agent; a gelatinizing agent; a defoaming agent and an initiator for photopolymerization.” *Id.*, [0084]; LGES-1003, ¶228.

[1c]

In the Farrugia-Narayan combination, the nanotubes (*e.g.*, oxidized, discrete nanotubes; *see* [1a]) have an aspect ratio of “greater than or equal to about 5,” “greater than or equal to about 10,” or “greater than or equal to about 100,” based on Narayan. *See* LGES-1008, [0014]; *see* §§IV.E.3-4; LGES-1003, ¶229.

The ranges of aspect ratios recited in element [1c] (“25 to 500”) overlaps and falls within the ranges of aspect ratios described in Narayan (*e.g.*, “greater than or equal to about 5,” “greater than or equal to about 10,” or “greater than or equal to about 100,” LGES-1008, [0014]). And the ’649 Patent provides no discussion, let alone any evidence, of any unexpected results or criticality of associated with nanotubes having an aspect ratio within the claimed range. LGES-1003, ¶¶230-232. Thus, Farrugia-Narayan presents a *prima facie* case and renders obvious the recited range of aspect ratios. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

Notably, Narayan can be relied on for disclosure of a range of aspect ratios overlapping—and thus rendering obvious—the claimed range of aspect ratios even to the extent the relied-upon ranges are not Narayan’s most preferred embodiment. *See* LGES-1008, [0014]; *see Merck & Co v. Biocraft Labs.*, 874 F.2d 804, 807 (Fed. Cir. 1989) (holding that a reference may be relied upon for all that it would have reasonably suggested to one having ordinary skill in the art, including non-

preferred embodiments); *In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004) (“The prior art’s mere disclosure of more than one alternative does not constitute a teaching away from any ... alternatives because such disclosure does not criticize, discredit, or otherwise discourage the solution claimed”).

[1d]

The nanotubes in the Farrugia-Narayan dispersions (*e.g.*, the unpolymerized mixture, the nanotube/polymer composite, and the toner; *see* [1pre]) are **multiwall**. *See* LGES-1007, claim 16 (“An emulsion/aggregation toner comprising: a crystalline polymer matrix comprising ***multi-walled carbon nanotubes***”); *see* [0028]; LGES-1003, ¶¶233-235. Farrugia’s experimental examples further confirm that the nanotubes in the composite are **multiwall** nanotubes (MWNTs). *See* LGES-1007, [0089]-[0097] (describing preparation of “***MWNTs***/Polyester Composite[s]”), [0104]-[0107]; LGES-1003, ¶235.

[1e]

The Farrugia-Narayan nanotube/polymer composite and unpolymerized mixture of nanotubes and monomer each renders obvious the claimed weight percentage of nanotubes

In the Farrugia-Narayan combination, Farrugia’s nanotube/polymer composite “comprises carbon nanotubes ***from about 2% to about 20% by weight*** of the composite,” or “***from about 0.05% to about 10% by weight*** of the polymer composite.” LGES-1007, [0018]; *see* [0053], claims 4-5, claim 5, claims 17-18,

[0093] (“Preparation of 0.075% MWNTs/Polyester Composite), [0096] (“Preparation of 0.185%MWNTs/Polyester Composite”), [0107]; LGES-1003, ¶¶236-250. That is, nanotubes **are present** in the combination nanotube/polymer composite **in the range of greater than zero to about 30% by weight based on the total weight of the dispersion** (*e.g.*, of the composite). LGES-1003, ¶¶236-250.

The range of weight percentages described in Farrugia (*e.g.*, “from about 2% to about 20% by weight” or “from about 0.05% to about 10% by weight,” LGES-1007, [0018]), and Farrugia’s specific weight percentage values (0.075%, 0.185%), fall within the recited range of weight percentages (“greater than zero to about 30% by weight”). LGES-1003, ¶¶238-239. In the combination, these weight percentages are thus relevant disclosures for the recited range of aspect ratios. *See Ineos USA LLC v. Berry Plastics Corp.*, 783 F.3d 865, 869 (Fed. Cir. 2015) (“When a patent claims a range, as in this case, that range is anticipated by a prior art reference if the reference discloses a point within the range”); *Titanium Metals Corp. of Am. v. Banner*, 778 F.2d 775, 782 (Fed. Cir. 1985); *In re Petering*, 301 F.2d 676, 682, 49 C.C.P.A. 993, 1001, 133 USPQ 275, 280 (1962)). Thus, the claimed range of weight percentages is obvious in view of the Farrugia-Narayan nanotube/polymer composite. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

Alternatively/additionally, a POSITA would have understood or found obvious that nanotubes **are present in the range of greater than zero to about 30% by weight** of the unpolymerized mixture. LGES-1003, ¶¶251-255. In Farrugia's process, the nanotubes and monomer are mixed, and then the mixture is polymerized to form the nanotube/polymer composite; other than loss of water due to the polymerization reaction, nothing is added to or removed from the mixture. *See* LGES-1007, [0045], [0093], [0096]; LGES-1003, ¶¶251-254. Thus, the weight percentage of nanotubes in the unpolymerized mixture is substantially equivalent to the weight percentage of nanotubes in the nanotube/polymer composite, which as discussed *supra*, renders obvious a weight percentage **in the range of greater than zero to about 30% by weight**. *See* LGES-1007, [0018], [0053], [0093], [0096], [0107], claims 4-5, claims 17-18; LGES-1003, ¶¶251-254.

To the extent that fewer than all of the nanotubes in the Farrugia-Narayan unpolymerized mixture or nanotube/polymer composite are oxidized, discrete carbon nanotubes, those oxidized, discrete carbon nanotubes constitute a portion of the 2-20% or 0.05-10% by weight of entire population of nanotubes. LGES-1007, [0018]; LGES-1003, ¶¶250, 255. Thus, the weight percentage of the oxidized, discrete carbon nanotubes still falls within the recited range of weight percentages.

The Farrugia-Narayan toner renders obvious the claimed weight percentage of nanotubes

In the Farrugia-Narayan combination, Farrugia describes preparation of toners with various weight percentages of multiwall carbon nanotubes, listed in Table 2, *infra*. LGES-1003, ¶256.

TABLE 2	
Resistivity of Carbon Black Toner Containing Crystalline Polyester Resins as a Function of MWNT Loading	
MWNT (wt % of total toner weight)	Resistivity (Ohm cm) (Expected Values)
0%	7.1×10^{12}
0.075%	1.0×10^{13}
0.185%	5.0×10^{13}
1.0%	1.0×10^{14}
1.5%	1.0×10^{15}
2.0%	1.0×10^{16}
3.0%	1.0×10^{15}
5.0%	1.0×10^{13}

Farrugia, Table 2

As shown in this table, Farrugia’s toners include nanotubes present in the range of ***greater than 0 to 5% by weight*** of the “total toner weight.” That is, nanotubes **are present** in the Farrugia-Narayan toner **in the range of greater than zero to about 30% by weight of the dispersion** (*e.g.*, of the toner). LGES-1003, ¶¶256-257.

The range of weight percentages recited in element [1e] (“greater than zero to about 30% by weight”) overlaps with the range of weight percentages described in Farrugia (up to 5% by weight; *see* Table 2). And the ’649 Patent provides no

discussion, let alone any evidence, of unexpected results or criticality of the claimed range of weight percentages. LGES-1003, ¶257. Thus, the claimed range of weight percentages is obvious in view of the Farrugia-Narayan toner. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

To the extent that fewer than all of the nanotubes in the Farrugia-Narayan toner are oxidized, discrete carbon nanotubes, those oxidized, discrete carbon nanotubes constitute a portion of the up to 5% by weight of entire population of nanotubes. LGES-1007, [0018]; LGES-1003, ¶258. Thus, the weight percentage of the oxidized, discrete carbon nanotubes still falls within the recited range of weight percentages.

(ii) Claim 2

In the combination, Farrugia describes that “[d]iscrete nanotubes, aggregates of nanotubes, or both discrete and aggregate nanotubes may be suitable for use according to the present disclosure.” LGES-1007, [0024]. That is, Farrugia’s dispersions (*e.g.*, the unpolymerized mixture, the nanotube/polymer composite, and the toner; *see* [1pre]) include either (1) “[d]iscrete nanotubes” or (2) a combination of “both discrete and aggregate nanotubes.” *Id.* When Farrugia’s composite includes “discrete nanotubes,” then, it does not include “both discrete and aggregate nanotubes,” indicating that substantially all of the nanotubes are discrete. LGES-1003, ¶259. A dispersion in which substantially all of the nanotubes are

discrete at least renders obvious a dispersion in which **at least 70 percent by weight of the nanotubes are discrete**, as claimed.¹² LGES-1003, ¶259 (citing LGES-1051, [0042]).

Alternatively/additionally, the particular weight percent of nanotubes that are discrete in a given composition is a straightforward design choice. LGES-1003, ¶261. In particular, a POSITA implementing a toner including nanotubes would have considered incorporation of various weight percentages of discrete nanotubes, constrained to the limited number of options between 0 and 100%. *Id.* And the specific “70 percent” recited in claim 2 presents no unexpected results or solution. *See Kuhle*, 526 F.2d at 555; *Chu*, 66 F.3d at 298-99.

Still alternatively/additionally, a POSITA would have understood or found obvious that **at least 70 percent by weight of the nanotubes are discrete** in the Farrugia-Narayan nanotubes based on Farrugia’s description of the functionalization (*e.g.*, oxidation) of the nanotubes. LGES-1003, ¶260. Farrugia describes that “functionalized carbon nanotubes” have various oxidation groups

¹² Petitioner has applied art that discloses features that are consistent with features Patent Owner contends in its Infringement Contentions to be covered by claim 2, and without conceding agreement to Patent Owner’s interpretation of this claim. *See* LGES-1050.

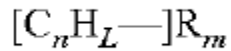
attached to their sidewalls, which, as described by Dr. Gido, can chemically and physically prevent the nanotubes from stacking into clumps. *See* [1a] and [2] of Ground 1A. A POSITA would have found it obvious that given this functionalization, substantially all of the nanotubes are discrete, *e.g.*, **at least 70% by weight of the nanotubes are discrete**. LGES-1003, ¶260.

(iii) Claim 3

As discussed in [1a], the nanotubes in the Farrugia-Narayan dispersions (*e.g.*, the unpolymerized mixture) are **discrete**, *e.g.*, that they are generally individual, separated nanotubes. A POSITA would have understood that nanotubes that are generally individual and separated are not aggregated into a clump, and thus are **free flowing particles**, *e.g.*, in that a given nanotube can flow freely relative to another nanotube in the dispersion. LGES-1003, ¶262.

(iv) Claim 4

In the combination, Farrugia describes that “functionalized carbon nanotubes can be directly prepared by ... oxidization,” which “produce[s] *carboxyl*, carbonyl and hydroxyl groups at the opened ends and defects on the side walls.” LGES-1007, [0028]. For instance, Farrugia describes that the “[f]unctionalized nanotubes” have the formula:



where R can be COOH (*i.e.*, **carboxylic acid**) or COOR', among others. *Id.*, [0029]-[0036]; *see* [0039] (“the carbon nanotubes are functionalized with **carboxylic acid moieties**”); LGES-1003, ¶¶263-265.

COOR' is an **ester** at least when “R' is ... alkyl, aryl, cycloalkyl, [] aralkyl, cycloaryl, or poly(alkylether).” LGES-1007, [0033]; LGES-1003, ¶266.

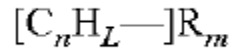
R can be COCl, which is acid chloride, *i.e.*, an **acyl halogen**. LGES-1007, [0031]; LGES-1003, ¶267.

That is, the **oxidized, discrete carbon nanotubes** (*see* [1a]) of both the nanotube/polymer composite and the toner include at least one of the following **oxidation species: carboxylic acid, amides, esters, and acyl halogens**. LGES-1003, ¶¶263-268.

These groups are **oxidation species** at least because the nanotubes are functionalized with these species as a result of an oxidation process. *See* LGES-1007, [0028] (“**oxidation chemistry** may be used ... to produce carboxyl, carbonyl and hydroxyl groups at the opened ends and defects on the side walls”), [0039]; LGES-1003, ¶268.

(v) Claim 5

See [4]. In the Farrugia-Narayan combination, the “[f]unctionalized nanotubes” have the formula:



where R can be OH (*hydroxyl*). LGES-1007, [0029]-[0036]; see [0028]

(“oxidation chemistry may be used ... to produce carboxyl, carbonyl and *hydroxyl groups* at the opened ends and defects on the side walls”); LGES-1003, ¶¶269-271.

That is, the **oxidized, discrete carbon nanotubes** (see [1a]) include a **hydroxyl oxidation species**. *Id.*

(vi) Claim 6

Both the combination nanotube/polymer composite and the unpolymerized mixture “comprise[] carbon nanotubes *from about 2% to about 20% by weight* of the composite,” *e.g.*, the oxidized, discrete carbon nanotubes are present in the composite **in the range of 15% to about 25% by weight**. LGES-1007, [0018]; see [0053], claims 4 and 17; LGES-1003, ¶¶272-273. See [1a], [1e].

The range of weight percentages recited in claim 6 (15% to about 25% by weight) overlaps the range of weight percentages in the Farrugia-Narayan combination (*e.g.*, about 2% to about 20% by weight; see LGES-1007, [0018]).

And the ’649 Patent provides no discussion, let alone any evidence, of unexpected results or criticality of the claimed range of weight percentages. LGES-1003,

¶274. Thus, claim 6 is obvious in view of Farrugia-Narayan. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

(vii) Claim 7

Both the combination nanotube/polymer composite and the unpolymerized mixture “comprise[] carbon nanotubes *from about 2% to about 20% by weight* of the composite,” *e.g.*, the oxidized, discrete carbon nanotubes are present in the composite **in the range of 18% to about 22% by weight**. LGES-1007, [0018]; *see* [0053], claims 4 and 17; LGES-1003, ¶¶275-276. *See* [1a], [1e].

The range of weight percentages recited in claim 7 (18% to about 22% by weight) overlaps the range of weight percentages in the Farrugia-Narayan combination (*e.g.*, about 2% to about 20% by weight; *see* LGES-1007, [0018]). And the '649 Patent provides no discussion, let alone any evidence, of unexpected results or criticality of the claimed range of weight percentages. LGES-1003, ¶277. Thus, claim 7 is obvious in view of Farrugia-Narayan. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

(viii) Claim 8

First, in the unpolymerized mixture, the **additive** is the excess first monomer. *See* [1b]; *see* LGES-1007, [0045]; LGES-1003, ¶278. The first monomer can be “ethylene glycol, diethylene glycol, triethylene glycol,

dipropylene glycol, tripropylene glycol,” which are glycols: **the additive is a glycol**. LGES-1007, [0044]; LGES-1003, ¶278.

Second, alternatively/additionally, in the combination nanotube/polymer composite and in the combination toner, the **additive** is the polymer matrix. *See* [1b]; *see* LGES-1007, [0020], [0027]-[0028], [0045]; LGES-1003, ¶279. The polymer matrix can be, among others, “poly(ethylene-sebacate), poly(propylene-sebacate), poly(butylene-sebacate), poly(pentylene-sebacate), poly(hexylene-sebacate), and poly(octylene-sebacate),” or “polyethylene-sebacate, polypropylene-sebacate, polybutylene-sebacate,” which are sebacates: **the additive is a sebacate**. LGES-1007, [0049]-[0050]; LGES-1003, ¶279. Other examples of the polymer matrix include “poly(ethoxylated bisphenol co-maleate), poly(butyloxyated bisphenol co-maleate), poly(co-propoxyated bisphenol co-ethoxylated bisphenol co-maleate), poly(1,2-propylene maleate),” which are maleates: **the additive is a maleate**. LGES-1007, [0050]; LGES-1003, ¶279. The polymer matrix can also be a polyester produced by reaction of a diol and a dicarboxylic acid, which generates dicarboxylic acids in the polymer: **the additive is dicarboxylic esters**. LGES-1007, [0043]-[0044]; LGES-1003, ¶280.

(ix) Claim 11

In the unpolymerized mixture, the excess first monomer and/or the second monomer is **an additive**. *See* [1b]; LGES-1007, [0045]. The excess first

monomer and the second monomer (the **additive**) each is **a solvent**, *e.g.*, a liquid in which the nanotubes are dispersed. LGES-1003, ¶¶281-283. For instance, Farrugia describes an experimental procedure in which nanotubes were “added to the *molten 1,9-nonanedio* [sic]” (a first monomer) and “well-dispersed in the diol.” LGES-1007, [0093]; *see* [0096]. Farrugia then describes that “*1,12-dodecanedioic acid*” (a second monomer) was added and “*melt[ed]*.” *Id.*, [0093]; *see* [0096]; LGES-1003, ¶¶281-283.

(x) Claim 12

The excess first monomer is **a solvent**. Examples of the first monomer include **substituted, nonhalogenated hydrocarbons**, *e.g.*, “diols having from 2 to 36 carbons.” LGES-1007, [0043]-[0044]; *see* [0093] (“1,9-nonandiol”); LGES-1003, ¶¶284, 286-289.

The excess second monomer is also **a solvent**. Examples of the second monomer include **substituted, nonhalogenated hydrocarbons**, *e.g.*, dicarboxylic acids. *See* LGES-1007, [0046]-[0047]; *see* [0093] (“1,12-dodecanedioic acid”); LGES-1003, ¶¶285-289.

(xi) Claim 13

In the unpolymerized mixture, the second monomer is an **additive**. *See* [1b]; *see* LGES-1007, [0045]-[0047]. Many of Farrugia’s second monomers are **reactive species capable of creating a thermoset polymer**. LGES-1003, ¶¶290-

294. For instance, Farrugia identifies sulfonated diacids (*e.g.*, sulfoethanediol, among many others) and equivalents such as sulfonated phthalic acids (*e.g.*, 4-sulfo-phthalic acid) and sulfonated phthalates (*e.g.*, dialkyl-4-sulfo-phthalate) as second monomers. *See* LGES-1007, [0046]-[0047]; LGES-1003, ¶291. As explained by Dr. Gido, diacids are reactive species; their acid groups react with other species to form polymers, such as polyesters, polyurethanes, or epoxies. LGES-1003, ¶292. Sulfonated diacids, in particular, are trifunctional monomers that also contain a sulfonate group, which provides a third reactive site on each monomer. These sulfonate groups enable generation of a crosslinked polymer, such as a crosslinked polyester, crosslinked polyurethane, or crosslinked epoxy. *Id.*, ¶293. Such crosslinked polymers are thermoset polymers. *Id.* That is, Farrugia's additive includes **reactive species capable of creating a thermoset polymer**, *e.g.*, including at least sulfonated diacids and their equivalents. *Id.*, ¶¶293-294.

Also in the unpolymerized mixture, the first monomer is an **additive**. *See* [1b]; *see* LGES-1007, [0045]. Many of Farrugia's first monomers are **reactive species capable of creating a thermoset polymer**. LGES-1003, ¶¶295-297. For instance, Farrugia's first monomer can be a trifunctional sulfonated diol (*e.g.*, 2-sulfo-1,3-propanediol), which, as discussed *supra*, is capable of creating a thermoset polymer. *See* LGES-1007, [0043]-[0044]; LGES-1003, ¶296.

Additionally, Farrugia's first monomer can be a non-sulfonated, difunctional diol (e.g., "diols having from 2 to 36 carbons") that, when reacted with the trifunctional second monomers discussed *supra*, are capable of creating a thermoset polymer. *See* LGES-1007, [0043]-[0044]; LGES-1003, ¶297.

(xii) Claim 14

Farrugia describes various **thermoset polyurethanes**: "the polyurethane of isocyanate and alcohol, the polyurethane of phenyl isocyanate with ethanol, the polyurethane of toluene diisocyanate and ethylene glycol." LGES-1007, [0048]. These polyurethanes are generated when the first monomer is a sulfonated diol (*see id.*, [0043]-[0044]) and the second monomer is a trifunctional isocyanate. *See id.*, [0048]; LGES-1003, ¶298.

(xiii) Claim 15

As discussed in [1b], in the Farrugia-Narayan toner, **the additive** is a wax, such as "polyolefin waxes, such as low molecular weight polyethylene, polypropylene, a fluorocarbon-based wax (Teflon), or Fischer-Tropsch wax, copolymers thereof, mixtures thereof, and the like." LGES-1007, [0071]. Each of these waxes is **a synthetic wax**. LGES-1003, ¶299.

(xiv) Claim 17

The Farrugia-Narayan toner includes "**colorants**," such as "pigment, dye, mixtures of pigment and dye, mixtures of pigments, mixtures of dyes, and the like." LGES-1007, [0068]; *see* Abstract, [0019], [0055], [0057], [0068]-[0070],

claims 1 and 11. Example colorants include “carbon black, lamp black, ... ultramarine,” or a variety of other colorants listed by Farrugia. *Id.*, [0069]; *see* [0106]. Farrugia’s colorants, *e.g.*, at least the pigments, are **at least one filler** in the combination toner. LGES-1003, ¶¶300-302.

(xv) Claim 18

The filler in the Farrugia-Narayan toner can be carbon black. *See* LGES-1007, [0069]; *see* [17]. Carbon black particles were well-known to have dimensions of less than about 20 microns. *See* LGES-1033, 2:29-35; LGES-1034, 2:3-6; LGES-1036, 11:10-25; LGES-1037, 8:32-40; LGES-1003, ¶303. Given this well-known size of carbon black, a POSITA would have understood or found obvious that **the filler** (carbon black) in the Farrugia-Narayan toner **has at least one dimension less than about 20 microns**. LGES-1003, ¶303.

The filler in the Farrugia-Narayan toner can be lamp black. *See* LGES-1007, [0069]; *see* [17]. Lamp black particles for pigment were well-known to have dimensions of less than about 20 microns. *See* LGES-1033, 2:29-35; LGES-1034, 1:63-2:6; LGES-1036, 11:10-25; LGES-1037, 8:32-40; LGES-1003, ¶304. Given this well-known size of lamp black, a POSITA would have understood or found obvious that **the filler** (lamp black) in the Farrugia-Narayan toner **has at least one dimension less than about 20 microns**. LGES-1003, ¶304.

The filler in the Farrugia-Narayan toner can be ultramarine. *See* LGES-1007, [0069]; *see* [17]. Ultramarine particles for pigment were well-known to have dimensions of less than about 20 microns. *See* LGES-1038, 5:48-49; LGES-1039, 3:33-48; LGES-1003, ¶305. Given this well-known size of ultramarine, a POSITA would have understood or found obvious that **the filler** (ultramarine) in the Farrugia-Narayan toner **has at least one dimension less than about 20 microns**. LGES-1003, ¶305.

(xvi) Claim 19

The **filler** in the Farrugia-Narayan toner can be **carbon black**. *See* LGES-1007, [0069]; *see* [17]; LGES-1003, ¶306.

(xvii) Claim 21

In the Farrugia-Narayan combination, Farrugia identifies “diols” as first monomers and diacids (*e.g.*, “dicarboxylic acids”) as second monomers. LGES-1007, [0044]-[0047]; LGES-1003, ¶307. A polymerization reaction between diols and dicarboxylic acids produces a polymer, *e.g.*, a polyester polymer. LGES-1003, ¶307. When the diols, dicarboxylic acids, or both, contain a sulfonate group, they are trifunctional monomers that act as **crosslinking agents** during the polymerization: the sulfonate can react with and link to an alcohol on the diols. *Id.* Some of the diols and dicarboxylic acids identified as Farrugia’s first and second monomers, respectively, are trifunctional monomers that contain sulfonate groups

and thus act as **cross linking agents**. For instance, the first monomer “2-sulfo-1,3-propanediol” and the second monomer “4-sulfo-phthalic acid” each is a trifunctional monomer capable of acting as a crosslinking agent. *Id.*

Alternatively/additionally, Farrugia identifies “crosslinked poly(styrene-acrylate) resins, ... crosslinked poly(styrene-methacrylate) resins, ... crosslinked poly(styrene-butadiene) resins,” and other crosslinked resins, as examples of the polymers in its nanotube/polymer composite. LGES-1007, [0050]. A POSITA would have understood or found obvious for the unpolymerized mixture to include a **crosslinking agent** enable creation of these crosslinked resins. LGES-1003, ¶308.

F. [GROUND 2B] – CLAIMS 22-23 ARE OBVIOUS OVER FARRUGIA, NARAYAN, AND NANYA

The sections below provide an introduction to Nanya and the Farrugia-Narayan-Nanya combination.¹³

1. Nanya describes toners including lubricants

Nanya describes “a dry-type toner that includes “a binder resin,” such as a “thermoplastic resin[],” “a coloring agent, and a carnauba wax serving as a lubricant or releasent.” *Id.*, 1:8-9, 2:30-3:37. The toner can include “auxiliary

¹³ Petitioner incorporates this discussion into Ground 2B.

components,” including “an electro-conductivity-imparting agent such as carbon black or tin oxide.” *Id.*, 4:8-16; LGES-1003, ¶¶309-311.

2. The Farrugia-Narayan-Nanya combination

In Farrugia-Narayan-Nanya, based on Nanya, carnauba wax, such as “[a] conventionally employed carnauba wax” or “a carnauba wax ... substantially free of free aliphatic acids” is incorporated into the toner, *e.g.*, in addition to or instead of the waxes identified by Farrugia. *See* LGES-1009, 2:38-45; LGES-1007, [0055], [0071]; LGES-1003, ¶312.

3. Reasons for the combination

A POSITA would have been motivated to incorporate carnauba wax into the combination toner. LGES-1003, ¶¶313-317.

First, a POSITA would have been motivated to pursue this implementation so that carnauba wax would “impart to [the] toner ... high resistance to the off-set phenomenon.” LGES-1009, 1:61-63; LGES-1003, ¶314.

Second, a POSITA would have been motivated to pursue this implementation to obtain the “excellent fixing ability at low temperatures” provided by carnauba wax. LGES-1009, 1:61-64; LGES-1003, ¶315.

Third, to the extent Nanya’s specific aliphatic acid-free carnauba wax is used, a POSITA would have been motivated to pursue this implementation to retain “high resistance to both the off-set and the winding phenomena,” while also

remaining “free from ... filming problem[s].” LGES-1009, 2:46-57; LGES-1003,

¶316. Moreover, a POSITA would have been motivated to incorporate Nanya’s specific carnauba wax because “a carrier does not adhere to” a toner including this wax. LGES-1009, 2:53-56; LGES-1003, ¶316.

Fourth, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (carnauba wax in a toner) to a known structure (the Farrugia-Narayan toner) to yield predictable results (toner including carnauba wax). LGES-1003, ¶317; *see KSR*, 550 U.S. at 417.

A POSITA would have expected success in incorporating carnauba wax into the combination toner for the following reasons. LGES-1003, ¶¶318-322.

First, Farrugia already contemplates inclusion of wax, and provides a non-limiting list of waxes, indicating that other waxes can be used successfully. *See* LGES-1007, [0071]; LGES-1003, ¶¶318-319.

Second, the materials systems in Nanya’s and Farrugia’s toners are similar. *See* LGES-1009, 3:1-38, 4:14-15; LGES-1007, [0018], [0047]-[0052]; LGES-1003, ¶320.

Third, use of carnauba wax in toners was well-known. *See* LGES-1028 (Aga), [0107]; LGES-1003, ¶321.

Fourth, both Farrugia and Nanya relate generally to toners. *See* LGES-1007, [0018]-[0019]; LGES-1009, 2:15-34; LGES-1003, ¶322.

4. Analysis

(i) Claim 22

The Farrugia-Narayan-Nanya toner, based on Nanya, includes a carnauba wax, such as “[a] conventionally employed carnauba wax” or “a carnauba wax ... substantially free of free aliphatic acids,” as an additive into the toner. LGES-1009, 2:38-45; LGES-1003, ¶323. Carnauba wax is **a plant derived natural wax**. *See* LGES-1011, [0051]; LGES-1028, [0107]; LGES-1003, ¶323.

(ii) Claim 23

See [21]; LGES-1003, ¶324.

V. PTAB DISCRETION SHOULD NOT PRECLUDE INSTITUTION

A. The *Fintiv* Factors Favor Institution—§314(a)

The Board should not discretionarily deny based on the *Fintiv* factors.

Factor 1 is neutral; neither party has requested a stay in co-pending litigation.

Factor 2 is neutral based on an expected Final Written Decision date in December 2025, which is within a few weeks of the likely trial date. In particular, the median time-to-trial date for EDTX is currently 21.4 months, which would suggest a likely trial date in November 2025. *See*

[fcms_na_distprofile1231.2023_0.pdf \(uscourts.gov\)](#), 35. Moreover, the Court set the trial date for December 2025. *See generally* LGES-1053.

Factor 3 favors institution; Petitioner has diligently filed this Petition months ahead of the one-year time bar, while the EDTX litigation is still in its early stages and investment minimal.

Factor 4 favors institution; if the Board institutes trial, Petitioner stipulates not to seek resolution in the district court of the same grounds presented in this Petition.

Factor 5 is neutral; parties in the parallel litigation are the same.

Factor 6 favors institution; the Petition presents a compelling case of invalidity.

B. The *Advanced Bionics* Test Favors Institution—§ 325(d)

This Petition presents new prior art and arguments against the Challenged Claims for which the file history contains no indication that the Office ever previously considered in connection with the '649 Patent. Indeed, none of Sun, Buretea, Kaji, Matsushita, Farrugia, Narayan, or Nanya—the only references applied in this Petition against the Challenged Claims—were previously cited or applied in a rejection during prosecution of the '649 Patent.

VI. PAYMENT OF FEES – 37 C.F.R. § 42.103

Petitioner authorizes the Patent and Trademark Office to charge Deposit Account No. 06-1050 for the fee set in 37 C.F.R. § 42.15(a) for this Petition and further authorizes payment for any additional fees to be charged to this Deposit Account.

VII. CONCLUSION

The Challenged Claims are unpatentable. Petitioner authorizes charge of fees to Deposit Account 06-1050.

VIII. MANDATORY NOTICES UNDER 37 C.F.R § 42.8(a)(1)

A. Real Party-In-Interest Under 37 C.F.R. § 42.8(b)(1)

Petitioner, LG Energy Solution, Ltd., is the real party-in-interest.

B. Related Matters Under 37 C.F.R. § 42.8(b)(2)

Petitioner is not aware of any disclaimers, reexamination certificates or petitions for *inter partes* review for the '649 Patent. The '649 Patent is the subject of a number of civil actions including: *Molecular Rebar Design, LLC et al v. LG Energy Solution, Ltd.*, 2-24-cv-00107 (EDTX) filed Feb. 16, 2024 (Pending); *Molecular Rebar Design, LLC et al v. Samsung Electronics Co., Ltd. et al*, 2-24-cv-00108 (EDTX) filed Feb. 16, 2024; and *Molecular Rebar Design, LLC et al v.*

LG Chem, Ltd. et al, 1-22-cv-01130 (DDE) filed August 29, 2022 (Dismissed).

C. Lead And Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3)

Petitioner provides the following designation of counsel.

Lead Counsel	Backup counsel
W. Karl Renner, Reg. No. 41,265 Fish & Richardson P.C. 60 South Sixth Street, Suite 3200 Minneapolis, MN 55402 Tel: 202-783-5070 Fax: 877-769-7945 Email: IPR18768-0210IP7@fr.com	Timothy Riffe, Reg. No. 43,881 Hyun Jin In, Reg. No. 70,014 Gretchen A. DeVries, Reg. No. 72,505 Fish & Richardson P.C. 60 South Sixth Street, Suite 3200 Minneapolis, MN 55402 Tel: 202-783-5070 Fax: 877-769-7945 PTABInbound@fr.com

D. Service Information

Please address all correspondence and service to the address listed above.

Attorney Docket No.: 18768-0210IP7

IPR of U.S. Patent No. 9,636,649

Petitioner consents to electronic service by email at IPR18768-0210IP7@fr.com

(referencing No. 18768-0210IP7 and cc'ing PTABInbound@fr.com).

Respectfully submitted,

Dated June 7, 2024.

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Counsel For Petitioner

CERTIFICATION UNDER 37 CFR § 42.24

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petition for *Inter Partes* Review totals 13,652 words, which is less than the 14,000 allowed under 37 CFR § 42.24.

Dated June 7, 2024.

/W. Karl Renner/

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Counsel For Petitioner

CERTIFICATE OF SERVICE

Pursuant to 37 CFR §§ 42.6(e)(4)(i) *et seq.* and 42.105(b), the undersigned certifies that on June 7, 2024, a complete and entire copy of this Petition for *Inter Partes* Review and all supporting exhibits were provided by Federal Express, to the Patent Owner by serving the correspondence address of record as follows:

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