United States Court of Appeals for the Federal Circuit

E.I. DUPONT DE NEMOURS & COMPANY, ARCHER DANIELS MIDLAND COMPANY,
Appellants

v.

SYNVINA C.V.,
Appellee

2017-1977

Appeal from the United States Patent and Trademark Office, Patent Trial and Appeal Board in No. IPR2015-01838.

Decided: September 17, 2018

MICHAEL J. FLIBBERT, Finnegan, Henderson, Farabow, Garrett & Dunner, LLP, Washington, DC, argued for appellants. Also represented by CHARLES COLLINS-CHASE.

PAUL M. RICHTER, JR., Pepper Hamilton LLP, New York, NY, argued for appellee. Also represented by MARK ALEXANDER CHAPMAN, Hunton Andrews Kurth LLP, New York, NY.

Before LOURIE, O'MALLEY, and CHEN, *Circuit Judges*.

LOURIE, *Circuit Judge*.

E. I. du Pont de Nemours and Company and Archer-Daniels-Midland Company (collectively, "DuPont") appeal from an *inter partes* review ("IPR") decision of the United States Patent and Trademark Office Patent Trial and Appeal Board (the "Board"). *See DuPont v. Furanix Techs. B.V.*, No. IPR2015-01838, Paper No. 43, slip op. (P.T.A.B. Mar. 3, 2017) ("*Decision*"). The Board held that DuPont failed to prove by preponderant evidence that claims 1–5 and 7–9 of U.S. Patent 8,865,921 ("'921 patent") would have been obvious at the time of the claimed invention. We conclude that the Board applied the wrong legal standards for obviousness, and reverse.

I. BACKGROUND

Synvina C.V. ("Synvina")[1] owns the '921 patent, directed to a method of oxidizing 5-hydroxymethylfurfural ("HMF") or an HMF derivative, such as 5-methylfurfural ("5MF") or 2,5-dimethylfuran ("DMF"), under specified reaction conditions to form 2,5-furan dicarboxylic acid ("FDCA"). '921 patent Abstract; *id.* col. 7 l. 65. Undisputedly, the oxidation of HMF and its derivatives to yield FDCA was known at the time of the claimed invention. The main issue on appeal is whether the reaction conditions claimed in the '921 patent—specifically, the choice of temperature, pressure, catalyst, and solvent—would have been obvious to a person of ordinary skill at the time of the invention.

A.

DuPont and Synvina are competitors in the production of FDCA for industrial use. FDCA has attracted

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[1] Synvina acquired the '921 patent from Furanix Technologies B.V. ("Furanix"), the patent owner during the IPR proceeding.

commercial interest because of its potential in the "green" chemical industry. Since FDCA can be produced from sugars using biological or chemical conversion, the U.S. Department of Energy has identified FDCA as a potential "building block[]" for "high-value bio-based chemicals or materials." U.S. Department of Energy, Top Value Added Chemicals from Biomass 1 (2004); *see* '921 patent col. 1 ll. 34–36.

The '921 patent claims a method of producing FDCA by oxidizing HMF or an HMF derivative with an oxygen-containing gas such as air. Claim 1 is illustrative and reads as follows:

> 1. A method for the preparation of 2,5-furan dicarboxylic acid comprising the step of contacting a feed comprising a compound selected from the group consisting of 5-hydroxymethylfurfural ("HMF"), an ester of 5-hydroxymethylfurfural, 5-methylfurfural, 5-(chloromethyl)furfural, 5-methylfuroic acid, 5-(chloromethyl)furoic acid, 2,5-dimethylfuran and a mixture of two or more of these compounds with an oxygen-containing gas, *in the presence of an oxidation catalyst comprising both Co and Mn, and further a source of bromine, at a temperature between 140° C. and 200° C. at an oxygen partial pressure of 1 to 10 bar, wherein a solvent or solvent mixture comprising acetic acid or acetic acid and water mixtures is present.*

'921 patent col. 7 l. 61–col. 8 l. 6 (emphasis added). Thus, claim 1 recites four relevant reaction conditions: (1) a temperature between 140°C and 200°C; (2) an oxygen partial pressure ("PO_2")[2] of 1 to 10 bar; (3) a solvent

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[2] PO_2 is the pressure in a gas mixture attributable to oxygen. Adding up the partial pressures of each gas in

comprising acetic acid; and (4) a catalyst comprising cobalt ("Co"), manganese ("Mn"), and bromine ("Br"). *Id.*

The specification describes the reaction conditions in further detail. We begin with temperature. At several points, the specification refers to the reaction occurring at temperatures "higher than 140° C." *Id.* Abstract, col. 2 ll. 41–42, col. 2 ll. 57–58, col. 5 ll. 18–19, col. 5 l. 39, col. 5 l. 57. When the specification refers to the temperature range in claim 1, it states that "[t]he temperature of the reaction mixture is at least 140° C., preferably from 140 and 200° C., most preferably between 160 and 190° C." *Id.* col. 4 ll. 56–58. But "[t]emperatures higher than 180°C. may lead to decarboxylation and to other degradation products." *Id.* col. 4 ll. 58–59.

Second, the specification provides the following guidance regarding reaction pressure:

> The pressure in a commercial oxidation process may vary within wide ranges. When a diluent is present, and in particular with acetic acid as diluent, the temperature and the pressure in such a process are not independent. The pressure is determined by the solvent (e.g., acetic acid) pressure at a certain temperature. The pressure of the reaction mixture is preferably selected such that the solvent is mainly in the liquid phase.

Id. col. 4 ll. 34–41. Because oxygen functions as the oxidant in the reaction, its partial pressure is particularly relevant. "In the case of continuously feeding and removing the oxidant gas to and from the reactor, *the oxygen partial pressure will suitably be between 1 and 30 bar or more preferably between 1 and 10 bar*." *Id.* col. 4 ll. 51–55 (emphasis added).

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the mixture gives the total air pressure. Air consists of about 21% oxygen. *See, e.g.*, *Decision*, slip op. at 17–18.

Third, as indicated above, "[t]he most preferred solvent is acetic acid." *Id.* col. 4 ll. 17–18. Fourth, the catalyst is preferably "based on both cobalt and manganese and suitably containing a source of bromine." *Id.* col. 3 ll. 38–40. The catalyst may also contain "one or more additional metals, in particular [zirconium] and/or [cerium]." *Id.* col. 3 ll. 57–58.

Several dependent claims recite narrower conditions than those recited in claim 1. Claims 2–5 each depend from claim 1. Claim 2 limits the starting material to HMF, esters of HMF, and a mixture thereof. *Id.* col. 8 ll. 7–10. Claims 3 and 4 recite a catalyst with an additional metal, such as zirconium ("Zr") or cerium ("Ce"). *Id.* col. 8 ll. 11–12, 60–61. And claim 5 recites a narrower temperature range between 160 and 190°C. *Id.* col. 8 ll. 62–63.

By conducting the oxidation reaction under the disclosed reaction conditions, the specification states that the inventors "surprisingly" achieved high yields of FDCA, *id.* col. 2 ll. 39–45, and both Furanix and Synvina have pointed to these yields as objective evidence of nonobviousness. The '921 patent reports yields for several reactions under the claimed conditions. Table 1 summarizes results for oxidizing HMF, an ester of HMF, 5-acetoxymethylfurfural ("AMF"), or a mixture of the two to produce FDCA. Multiple experiments were conducted at a temperature of 180°C and a pressure of 20 bars air in an acetic acid solvent. *Id.* col. 6 ll. 34–46. The highest yield of 78.08% was obtained with only HMF as a reactant, while the lowest was 46.85% using AMF alone. *Id.* Table 1.

Table 2 shows the FDCA yields reported in table 1 for the AMF oxidation reactions compared to prior art processes conducted at lower temperatures and a pressure of 30 bars air. *Id.* Table 2; *id.* col. 6 ll. 50–62. FDCA yields achieved using prior art processes were "lower than the

results obtained at higher temperature." *Id.* col. 6 ll. 50–61.

Table 3 shows FDCA yields for six experiments when HMF derivatives 5MF or DMF are oxidized with air. The temperature was 180°C, the air pressure was 50 bars, and the solvent was acetic acid. *Id.* col. 6 l. 66–col. 7 l. 12. Again, the concentration of bromine in the catalyst varied across experiments. Reported FDCA yields for 5MF were 42.62% and 39.94%. *Id.* Table 3. For DMF, FDCA yields ranged from 7.19% to 16.17%. *Id.*

In addition to claiming methods of producing FDCA, the '921 patent also claims certain post-production processes. Claim 7 is independent and recites producing FDCA under the conditions in claim 1, and then "esterifying the thus obtained product." *Id.* col. 9 ll. 1–14. Claims 8 and 9 depend from claim 7 and recite further details of the esterification not relevant to this appeal. *Id.* col. 9 ll. 15–19. The specification recognizes that "[t]he esterification of [FDCA] is known." *Id.* col. 5 ll. 42–48 (citing U.S. Patents 2,673,860 and 2,628,249); *see also id.* col. 5 l. 62–col. 6 l. 2 (citing GB 621,971).

B.

DuPont petitioned for IPR of the '921 patent. The petition asserted several grounds of obviousness, two of which are relevant on appeal: (1) claims 1–5 over the '732 publication,[3] alone or in combination with RU '177[4] and the '318 publication;[5] and (2) claims 7–9 over the '732 publication in view of Applicants Admitted Prior Art, or

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[3] International Publication WO 01/72732.

[4] Inventor's Certificate RU-448177.

[5] U.S. Patent Application Publication 2008/0103318.

additionally Lewkowksi[6] and/or Oae,[7] and optionally in view of RU '177 and the '318 publication.

The Board instituted review of claims 1–5 and 7–9 based on grounds 1 and 2 above, but did not institute review of the other claims or grounds.[8] *DuPont v. Furanix Techs. B.V.*, No. IPR2015-01838, Paper No. 10, slip op. at 15, 19 (P.T.A.B. Mar. 9, 2016) ("*Institution Decision*").

Each of the three references relevant to claims 1–5 disclosed oxidizing HMF or an HMF derivative to produce FDCA, but did so under somewhat different conditions. First, the '732 publication disclosed oxidizing HMF to FDCA. It included "preferred temperatures" of "about 50° to 250°C, most preferentially about 50° to 160°C." J.A. 2360. Like the '921 patent, the '732 publication indicated that the reaction pressure "is such to keep the solvent mostly in the liquid phase." *Id.* Specifically, the reference disclosed that an air pressure of 1000 psi "gave good yields of [FDCA]." J.A. 2368. 1000 psi amounts to a PO_2 of approximately 14.5 bars. The disclosed solvent was "preferably acetic acid," J.A. 2357, and "the catalyst can be comprised of Co and/or Mn, and Br, and optionally Zr,"

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[6] Jaroslaw Lewkowski, *Synthesis, Chemistry and Applications of 5-Hydroxymethylfurfural and Its Derivatives*, ARKIVOC 17 (2001).

[7] Shigeru Oae, *A Study of the Acid Dissociation of Furan- and Thiophenedicarboxylic Acids and of the Alkaline Hydrolysis of Their Methyl Esters*, 38(8) Soc. Jpn. 1247 (1965).

[8] Neither party has requested any action based on the Supreme Court's decision in *SAS Institute Inc. v. Iancu*, 138 S. Ct. 1348 (2018), and we do not order such action *sua sponte*, *see PGS Geophysical AS v. Iancu*, 891 F.3d 1354, 1361–63 (Fed. Cir. 2018).

J.A. 2358. Reported FDCA yields ranged from 14% to 58.8%.

Second, RU '177 disclosed oxidizing 5MF to form FDCA. It included a method where the oxidation reaction "is conducted at the temperature of 115–140°C and air pressure of 10–50 atm." J.A. 2440. An air pressure of 10–50 atm roughly corresponds to a PO_2 of 2.1–10.5 bars.[9] RU '177 also generally recites an "aliphatic carboxylic acid" as the solvent, and an example in the specification specifically uses acetic acid. *Id.* The catalyst in RU '177 is "a mixture of cobalt acetate and manganese acetate, as well as bromine-containing compounds, such as ammonium bromide." *Id.* Purportedly, the process "has a number of advantages compared to prior art: it utilizes readily available and inexpensive reagents as the initial compound and catalysts; [and] the method is a one-step process." J.A. 2439. FDCA yields reportedly ranged from 23–36%.

Third, the '318 publication taught the oxidation of HMF to make FDCA. The reaction temperature was "from about 50° C. to about 200° C," with a preferred range of 100–160°C. J.A. 2484, 2486. "A preferred pressure can typically be in the range of 150–500 psi," J.A. 2486, corresponding to a PO_2 range in air of roughly 2.17–7.24 bars. Unlike the '921 patent and the other references, the '318 publication taught using water as a solvent and a platinum catalyst.[10] Under these conditions, the '318 publication reported yields "as high as 98%." J.A. 2486.

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[9] 1 bar is approximately equal to 1 atm.

[10] The '318 publication did indicate, however, that "[w]here an acidic aqueous solution solvent system is utilized, an appropriate acid can be added such as, for example, acetic acid." J.A. 2486.

The table below summarizes the reaction conditions disclosed in claim 1 of the '921 patent and in the RU '177, '732, and '318 references. For simplicity and to enable comparison between pressure ranges, we restate only the PO_2 ranges in bars under the assumption that air is the oxidant.

Reference	*Temperature*	*Pressure*	*Solvent*	*Catalyst*
'921 patent	Between 140–200°C	1–10 bars	Acetic acid	Co/Mn/Br
RU '177	115–140°C	2.1–10.5 bars	Acetic acid	Co/Mn/Br
'732	50–250°C, preferably 50–160°C	14.5 bars	Acetic acid	Co/Mn/Br, optionally Zr
'318	50–200°C, preferably 100–160°C	2.17–7.24 bars	Water	Pt

Two additional references, Lewkowski and Oae, are relevant to the FDCA esterification claims 7–9. Consistent with the '921 patent's acknowledgment that esterification of FDCA was known at the time of the invention, '921 patent col. 5 l. 42, Lewkowski and Oae both disclosed esterifying FDCA.

C.

In its final written decision, the Board held the instituted claims not unpatentable as obvious. The Board rejected DuPont's contention that a burden-shifting framework applied, reasoning that our decisions in *In re Magnum Oil Tools International, Ltd.*, 829 F.3d 1364, 1375 (Fed. Cir. 2016), and *Dynamic Drinkware, LLC v. National Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir.

2015), foreclosed such a framework in an IPR. *Decision*, slip op. at 15.

Although the Board recognized that the prior art disclosed oxidizing HMF or its derivatives to FDCA under reaction conditions that overlapped with those claimed in the '921 patent, it found that "none of the references relied upon by Petitioners expressly taught a process in which HMF or its derivatives were oxidized to FDCA using a Co/Mn/Br catalyst at a reaction temperature of between 140°C and 200°C while also maintaining the [PO_2] between 1 and 10 bar." *Id.* at 16. Furthermore, the Board held that DuPont failed to prove that "reaction temperature and [PO_2] were recognized as result-effective variables in the prior art, or that the adjustment of those parameters to within the claimed ranges would have been a matter of routine experimentation." *Id.* at 25.

The Board considered objective evidence of nonobviousness, but found "that evidence to be less probative in supporting a conclusion of non-obviousness." *Id.* at 15. Primarily, then-patent owner Furanix alleged that the reaction conditions claimed in the '921 patent achieved unexpectedly high yields of FDCA. *Id.* at 25–26. While the Board recognized that the reaction conditions recited in claim 1 "can lead to higher FDCA yields at least in some circumstances," *id.* at 29, the Board observed the following weaknesses in the evidence of unexpected results: (1) Furanix relied only on results from a single PO_2 value, not values commensurate with the scope of the claim; (2) Furanix did not demonstrate how the increased yields would be considered a difference in kind rather than degree; and (3) other, unclaimed parameters such as reaction time and catalyst concentration could have contributed to higher yields, and those parameters were not held constant between the experiments from table 1 and experiments conducted under prior art conditions, *id.* at 29–30. Thus, ultimately the Board found that Furanix

failed to establish unexpected results or criticality. *Id.* at 30.

Likewise, the Board determined that the process claimed in the '921 patent did not solve a long-felt need. *Id.* at 31. Nor did the Board find that DuPont copied the '921 patent. *Id.* at 32.

DuPont appealed, challenging the Board's conclusion of nonobviousness. In its responsive brief, Synvina asserted that DuPont lacks standing to appeal. Because Synvina's challenge to standing implicates our jurisdiction, we first decide the standing issue, and then turn to the merits.

DISCUSSION

I. Standing

Synvina argues that DuPont lacks standing to appeal the Board's decision to this court because DuPont has not suffered an actual or imminent injury in fact. Since no action for infringement of the '921 patent has been brought against DuPont, Synvina contends that DuPont can posit only speculative future harm. According to Synvina, such hypothetical injury is insufficient to meet its burden to prove standing.

DuPont responds that a specific threat of infringement is not necessary for an appellant to demonstrate injury in fact. Rather, DuPont contends that an appellant must only face a significant risk of infringement liability, and that it faces such a risk for several reasons: (1) DuPont has built a demonstration plant to produce FDCA and an FDCA ester ("FDME"), and the plant is capable of operating under conditions within the claimed ranges of the '921 patent; (2) Synvina is a competitor that alleged before the Board that Archer-Daniels-Midland Company's ("ADM") processes for producing FDCA were "embraced by the claims in the '921 patent," Reply Br. 25–26 (quoting J.A. 2216); and (3) Synvina rejected DuPont's

request for a covenant not to sue. According to DuPont, these facts are sufficient to prove an actual or imminent injury in fact.

We have jurisdiction to review final decisions of the Board under 28 U.S.C. § 1295(a)(4)(A). However, as an Article III court, we are only empowered to adjudicate "Cases" and "Controversies," U.S. Const. Art. III, § 2, "appropriately resolved through the judicial process," *Lujan v. Defenders of Wildlife*, 504 U.S. 555, 560 (1992) (internal quotation marks omitted). To establish a case or controversy, an appellant must meet "the irreducible constitutional minimum of standing," *id.*, even if there is no such requirement to appear before the administrative agency being reviewed, *Consumer Watchdog v. Wis. Alumni Research Found.*, 753 F.3d 1258, 1261 (Fed. Cir. 2014).[11] Standing requires an appellant to have "(1) suffered an injury in fact, (2) that is fairly traceable to the challenged conduct of the defendant, and (3) that is likely to be redressed by a favorable judicial decision." *Spokeo, Inc. v. Robins*, 136 S. Ct. 1540, 1547 (2016). As the party seeking judicial review, the appellant bears the burden of proving that it has standing. *Phigenix, Inc. v. Immunogen, Inc.*, 845 F.3d 1168, 1171 (Fed. Cir. 2017).

Under the circumstances here, we agree with DuPont that it has standing to appeal the Board's decision. As in the declaratory judgment context, a petitioner who appeals from an IPR decision need not face "a specific threat of infringement litigation by the patentee" to establish

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[11] However, "where Congress has accorded a procedural right to a litigant, such as the right to appeal an administrative decision, certain requirements of standing—namely immediacy and redressability, as well as prudential aspects that are not part of Article III—may be relaxed." *Consumer Watchdog*, 753 F.3d at 1261 (citing *Massachusetts v. EPA*, 549 U.S. 497, 517–18 (2007)).

jurisdiction. *ABB Inc. v. Cooper Indus., LLC*, 635 F.3d 1345, 1348 (Fed. Cir. 2011). Rather, on appeal the petitioner must generally show a controversy "of sufficient immediacy and reality" to warrant the requested judicial relief. *Id.* (citing *MedImmune, Inc. v. Genentech, Inc.*, 549 U.S. 118, 127 (2007)).

Such a controversy exists here because DuPont currently operates a plant capable of infringing the '921 patent. After Synvina challenged DuPont's standing in its responsive brief,[12] DuPont submitted several declarations in support of standing. In the declarations, three scientists employed by ADM or DuPont collectively averred that: (1) in January 2016 ADM and DuPont publicly announced a plan to build a 60 ton-per-year demonstration plant to produce FDME, (2) FDME would be produced at the plant by dehydrating fructose to compounds including HMF which are then oxidized to FDCA and esterified to FDME, (3) the process would occur in an acetic acid solvent and with a Co/Mn/Br catalyst within a temperature range of 120–250°C (preferably 170–190°C) and a PO_2 range of 0.02–100 bars (preferably 0.2–21 bars), and (4) the plant was expected to be mechanically complete by January 2018 and online by the second quarter of 2018. At oral argument, counsel for DuPont confirmed that the plant opened on April 30, 2018 and is currently in operation. Oral Arg. at 1:00–1:30, http://oralarguments.cafc.uscourts.gov/default.aspx?fl=2017-1977.mp3.

Taken together, these facts demonstrate that DuPont, an avowed competitor of patent owner Synvina, has taken and "plans to take . . . action that would implicate" the '921 patent, *Phigenix*, 845 F.3d at 1173–74, including significant "involvement in research [and] commercial

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[12] Synvina did not earlier move to dismiss for lack of standing.

activities involving" the claimed subject matter of the '921 patent, *Consumer Watchdog*, 753 F.3d at 1260. According to DuPont's declarations, the process conducted at its plant uses the same reactants to generate the same products using the same solvent and same catalysts as the '921 patent. Likewise, the temperature and PO_2 ranges used at the plant overlap with those claimed in the '921 patent. At the very least, this indicates that DuPont "is engaged or will likely engage 'in an[] activity that would give rise to a possible infringement suit.'" *JTEKT Corp. v. GKN Auto. Ltd.*, 898 F.3d 1217, 1220 (Fed. Cir. 2018) (alteration in original) (quoting *Consumer Watchdog*, 753 F.3d at 1262). Synvina's allegations of copying before the Board and its refusal to grant DuPont a covenant not to sue further confirm that DuPont's risk of liability is not "conjectural" or "hypothetical." *See Lujan*, 504 U.S. at 560.

In sum, because DuPont "has concrete plans" for present and "future activity that create[] a substantial risk of future infringement or likely cause the patentee to assert a claim of infringement," *JTEKT*, 898 F.3d at 1221, we conclude that DuPont has satisfied the injury in fact requirement for Article III standing. As there is no dispute that the risk of infringement liability is attributable to Synvina's '921 patent, and that the risk could be redressed by our review of the Board's decision, we conclude that DuPont has Article III standing.[13] We therefore proceed to the merits.

II. Obviousness

Our review of a Board decision is limited. *In re Baxter Int'l, Inc.*, 678 F.3d 1357, 1361 (Fed. Cir. 2012). We

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[13] However, beyond the issue of standing, we make no judgment on whether DuPont has infringed or is infringing the '921 patent.

review the Board's legal determinations *de novo*, *In re Elsner*, 381 F.3d 1125, 1127 (Fed. Cir. 2004), but we review the Board's factual findings underlying those determinations for substantial evidence, *In re Gartside*, 203 F.3d 1305, 1316 (Fed. Cir. 2000). A finding is supported by substantial evidence if a reasonable mind might accept the evidence as adequate to support the finding. *Consol. Edison Co. of N.Y. v. NLRB*, 305 U.S. 197, 229 (1938).

DuPont asserts that the Board erred in its obviousness analysis primarily in two ways. First, DuPont argues that the Board misinterpreted our precedent and erroneously refused to apply a burden-shifting framework in the context of overlapping prior-art ranges from cases such as *In re Peterson*, 315 F.3d 1325 (Fed. Cir. 2003), and *Ormco Corp. v. Align Technology, Inc.*, 463 F.3d 1299 (Fed. Cir. 2006). Second, DuPont contends that the Board invoked a "result-effective variable" requirement inconsistent with precedent. Given these errors, DuPont argues that the Board's decision should be reversed with respect to each instituted claim.

Synvina responds that the Board applied the proper standards for obviousness, and that substantial evidence supports the Board's findings in favor of patentability of the challenged claims.

A.

The legal principle at issue in this case is old. For decades, this court and its predecessor have recognized that "where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation." *In re Aller*, 220 F.2d 454, 456 (CCPA 1955); *see also, e.g.*, *In re Geisler*, 116 F.3d 1465, 1469–70 (Fed. Cir. 1997); *In re Woodruff*, 919 F.2d 1575, 1578 (Fed. Cir. 1990). Thus, "[n]ormally, it is to be expected that a change in temperature, or in concentration, or in both, would be an un-

patentable modification." *Aller*, 220 F.2d at 456. A more specific application of this general principle is that "[a] *prima facie* case of obviousness typically exists when the ranges of a claimed composition overlap the ranges disclosed in the prior art." *Peterson*, 315 F.3d at 1329 (collecting cases). We have said that such overlap creates a presumption of obviousness. *See Galderma Labs., L.P. v. Tolmar, Inc.*, 737 F.3d 731, 737–38 (Fed. Cir. 2013); *Ormco*, 463 F.3d at 1311; *Iron Grip Barbell Co. v. USA Sports, Inc.*, 392 F.3d 1317, 1322 (Fed. Cir. 2004).

There are several ways by which the patentee may rebut that presumption. First, a modification of a process parameter may be patentable if it "produce[s] a new and unexpected result which is different in kind and not merely in degree from the results of the prior art." *Aller*, 220 F.2d at 456. A claimed range that demonstrates such unexpected results is referred to as a "critical" range, and the patentee has the burden of proving criticality. *Id.* Second, and relatedly, a patentee may rebut the presumption of obviousness by showing that the prior art taught away from the claimed range. *Ormco*, 463 F.3d at 1311. Third, a change to a parameter may be patentable if the parameter was not recognized as "result-effective." *In re Applied Materials, Inc.*, 692 F.3d 1289, 1295 (Fed. Cir. 2012) (citing *In re Antonie*, 559 F.2d 618, 620 (CCPA 1977)). But "[a] recognition in the prior art that a property is affected by the variable is sufficient to find the variable result-effective." *Id.* at 1297. Fourth, we have reasoned that disclosure of very broad ranges may not invite routine optimization. *Genetics Inst., LLC v. Novartis Vaccines & Diagnostics, Inc.*, 655 F.3d 1291, 1306 (Fed. Cir. 2011) (holding that ordinary motivation to optimize did not apply where disclosure was 68,000 protein variants including 2,332 amino acids); *Peterson*, 315 F.3d at 1330 n.1. As we explain, the presumption of obviousness applies here, and none of the means for rebutting it has been shown.

B.

We first address DuPont's argument that the Board erred by not applying the burden-shifting framework applicable to overlapping range cases. Synvina argues that the Board correctly concluded that our decision in *Magnum Oil* prohibited any burden-shifting framework from applying in an IPR.

We agree with DuPont that the Board erred in concluding that the type of burden-shifting framework consistently applied in our overlapping range cases was implicitly foreclosed by subsequent cases not addressing this framework. We have articulated the relevant framework as follows. "[W]here there is a range disclosed in the prior art, and the claimed invention falls within that range, the burden of production falls upon the patentee to come forward with evidence" of teaching away, unexpected results, or other pertinent evidence of nonobviousness. *Galderma*, 737 F.3d at 738; *see Allergan, Inc. v. Sandoz Inc.*, 796 F.3d 1293, 1304–05 (Fed. Cir. 2015) (citing *Galderma*, 737 F.3d at 737–38); *Ormco*, 463 F.3d at 1311 ("Where a claimed range overlaps with a range disclosed in the prior art, there is a presumption of obviousness. The presumption can be rebutted if it can be shown that the prior art teaches away from the claimed range, or the claimed range produces new and unexpected results.") (citations omitted)); *Iron Grip Barbell*, 392 F.3d at 1322 (same). The factfinder then assesses that evidence, along with all other evidence of record, to determine whether a patent challenger has carried its burden of persuasion to prove that the claimed range was obvious.

Galderma, *Allergan*, *Ormco*, and *Iron Grip Barbell* each applied this concept in a district court case. The same basic framework is also applicable to examination at the United States Patent and Trademark Office ("PTO").

See, e.g., *Peterson*, 315 F.3d at 1329–30; *Geisler*, 116 F.3d at 1469; *Woodruff*, 919 F.2d at 1578.

To our knowledge, this is the first time we have been asked to decide whether this framework governs in the IPR context. The Board addressed this issue in a single paragraph, and did not cite, let alone discuss, the cases above applying the framework in both district court and PTO proceedings. Instead, the Board interpreted two more recent cases, *Dynamic Drinkware* and *Magnum Oil*, as prohibiting any burden-shifting framework from applying in an IPR. The Board erred, as these two cases did not overturn the procedural scheme for overlapping range cases.

Neither *Dynamic Drinkware* nor *Magnum Oil* involved overlapping ranges. The issue in *Dynamic Drinkware* was the allocation of the burdens of persuasion and production for anticipation and entitlement to an earlier priority date in an IPR. 800 F.3d at 1378–80. We held that the IPR petitioner "had the burden of persuasion to prove unpatentability by a preponderance of the evidence, and this burden never shifted." *Id.* at 1379. The burden of production, however, could shift with respect to the presentation of evidence of anticipation or priority date. *Id.* at 1379–80. While we recognized that different evidentiary standards applied between district court litigation and IPRs, that difference did "not alter the shifting burdens between the parties" because in both a district court case and an IPR the patent challenger has the burden of proving unpatentability. *Id.* at 1379. In other words, we applied consistent procedural schemes between district court litigation and IPRs, as the only relevant difference was in the quantum of evidence necessary to prove unpatentability.

In *Magnum Oil*, we rejected the PTO's argument that when the Board institutes IPR, and so concludes the petitioner has met the "reasonable likelihood of success"

standard, that conclusion "operates to shift the burden of producing evidence of nonobviousness to the patentee." 829 F.3d at 1374. We observed that there was no dispute that the burden of persuasion remained with the patent challenger. *Id.* at 1375. Although we recognized that the burden of production may shift in certain circumstances in an IPR, *id.* at 1375–76 (discussing *Dynamic Drinkware*, 800 F.3d at 1379), we held that this burden did not shift to the patentee to generally prove nonobviousness following institution, *id.* at 1376. As in *Dynamic Drinkware*, we did not discuss our case law concerning overlapping ranges or the procedural framework relating to them.

Synvina points to broader statements in *Magnum Oil* purportedly in tension with applying any burden shifting framework in the obviousness context. Appellee Br. 40 (citing *Magnum Oil*, 829 F.3d at 1376 ("Where, as here, the only question presented is whether due consideration of the four *Graham* factors renders a claim or claims obvious, no burden shifts from the patent challenger to the patentee.")). But such general statements must be interpreted in context, as must the specific question we address here. The point of our overlapping range cases is that, in the absence of evidence indicating that there is something special or critical about the claimed range, an overlap suffices to show that the claimed range was disclosed in—and therefore obvious in light of—the prior art. Our use of the term "presumption" or the phrase "burden-shifting framework" is merely a recognition of the practical reality that a patent challenger would have every incentive to point out the existence of an overlapping range, and virtually none to differentiate the claimed range from what was disclosed in the prior art. Importantly, the language employed in our overlapping range cases does not shift the burden of persuasion to the patentee to prove nonobviousness by, for example, pointing to evidence of criticality or unexpected results. All our case law states is that, absent a reason to conclude other-

wise, a factfinder is justified in concluding that a disclosed range does just that—discloses the entire range.

While a patentee technically has no "burden" to do anything to defend the validity of its patent other than hold the patent challenger to its own burden of persuasion, that burden of persuasion is necessarily satisfied when there is no evidentiary reason to question the prior art's disclosure of a claimed range. *Magnum Oil* is not to the contrary.

Since *Dynamic Drinkware* and *Magnum Oil* did not alter the framework governing overlapping range cases, and Synvina presents no persuasive argument supporting a special rule for IPRs, we conclude that the same scheme applicable to district court adjudications and PTO examinations controls in IPR proceedings. Thus, "where there is a range disclosed in the prior art, and the claimed invention falls within that range, the burden of production falls upon the patentee to come forward with evidence" of teaching away, unexpected results or criticality, or other pertinent objective indicia indicating that the overlapping range would not have been obvious in light of that prior art. *Galderma*, 737 F.3d at 738.

C.

Next, we address DuPont's argument that the Board erred in holding that the PO_2 and temperature of a known oxidation reaction were not "result-effective variables." Synvina disagrees, arguing that the Board properly concluded that DuPont failed to prove that the claimed parameters were result-effective.

We agree with DuPont that the Board erred in its analysis of whether PO_2 and temperature were result-effective variables. As we explain, the Board did not apply the proper legal standard for result-effective variables, and, under the correct standard, PO_2 and temperature are result-effective variables.

The idea behind the "result-effective variable" analysis is straightforward. Our predecessor court reasoned that a person of ordinary skill would not always be motivated to optimize a parameter "if there is no evidence in the record that the prior art recognized that [that] particular parameter affected the result." *Antonie*, 559 F.2d at 620. For example, in *Antonie* the claimed device was characterized by a certain ratio, and the prior art did not disclose that ratio and was silent regarding one of the variables in the ratio. *Id.* at 619. Our predecessor court thus reversed the Board's conclusion of obviousness. *Id.* at 620.

Antonie described the situation where a "parameter optimized was not recognized to be a result-effective variable" as an "exception" to the general principle in *Aller* that "the discovery of an optimum value of a variable in a known process is normally obvious." *Id.* at 620. Our subsequent cases have confirmed that this exception is a narrow one. Indeed, we have located no case where this court relied on a variable not being result-effective in an obviousness analysis. In summarizing the relevant precedent from our predecessor court, we observed in *Applied Materials* that "[i]n cases in which the disclosure in the prior art was insufficient to find a variable result-effective, there was essentially *no* disclosure of the relationship between the variable and the result in the prior art." 692 F.3d at 1297. Likewise, if the prior art does recognize that the variable affects the relevant property or result, then the variable is result-effective. *Id.* ("A recognition in the prior art that a property is affected by the variable is sufficient to find the variable result-effective."). And "the prior art need not provide the exact method of optimization for the variable to be result-effective." *Id.*

Although the Board correctly articulated the basic standard for result-effective variables, *Decision*, slip op. at 16–17 (citing *Applied Materials*, 692 F.3d at 1297), it did

not follow it. Rather, the Board appears to have required DuPont to prove that the disclosures in the prior art "necessarily required" the variable to be within the claimed range, or that the variables "predictably affected FDCA yields." *Id.* at 19. But that was not DuPont's burden. Under the applicable standard, DuPont needed to show that it was recognized in the prior art, either expressly or implicitly, that the claimed oxidation reaction was affected by reaction temperature and PO_2. *See Applied Materials*, 692 F.3d at 1297; *Antonie*, 559 F.2d at 620. And there does not appear to be a legitimate dispute that temperature and PO_2 were understood to affect the claimed oxidation reaction, which was known at the time of invention.

Rather, each reference relevant to claims 1–5 expressly disclosed appropriate or preferred temperatures and air pressures for the reaction, indicating that persons of ordinary skill understood that the reaction was affected by temperature and pressure. The testimony of then-patent owner Furanix's expert was consistent with this understanding. He explained that temperature generally affects the rate of chemical reactions, and if a temperature is too low, the reaction may not occur at all. J.A. 3852–53. Similarly, Furanix's expert testified that the partial pressure of oxygen would affect the reaction rate because oxygen is a reactant. J.A. 3853–54**.** Moreover, the Board itself reasoned that a person of ordinary skill would have expected that increasing PO_2 would increase oxygen as a reactant and thereby increase yields of FDCA. *Decision*, slip op. at 21. Synvina's counsel repeated this line of reasoning at oral argument. Oral Arg. at 29:10–29:35. Thus, it cannot be said that "there was essentially *no* disclosure of the relationship between" temperature, PO_2, and the claimed oxidation reaction. *Applied Materials*, 692 F.3d at 1297. There was such disclosure.

Altogether, the evidence in this case supports the unremarkable fact that an oxidation reaction is affected by temperature and PO_2. No substantial evidence supports the Board's contrary finding that it made under the wrong legal standard.[14] On the record evidence, only one finding was permissible: temperature and PO_2 were recognized as result-effective variables.

D.

Having articulated the legal standards applicable to this case, we apply them to the challenged claims.

1. Claims 1–5

As previously discussed, claim 1 recites oxidizing HMF, an HMF derivative such as 5MF, or an ester of HMF to FDCA under the following conditions: (1) a temperature between 140 and 200°C; (2) a PO_2 of 1–10 bars; (3) a solvent comprising acetic acid; and (4) a catalyst comprising cobalt, manganese, and bromine. '921 patent col. 7 l. 61–col. 8 l. 6. The Board held that the combination of the '732 publication, RU '177, and the '318 publication did not render claims 1–5 unpatentable as obvious. Under the applicable legal standards, we disagree with the Board's conclusion, and reverse.

The '732 publication disclosed oxidizing HMF to FDCA with a cobalt, manganese, and bromine catalyst and an acetic acid solvent. RU '177 similarly disclosed the oxidation of 5MF to FDCA, also with a Co/Mn/Br catalyst and an acetic acid solvent. Thus, the only relevant difference between these references and claim 1 is in

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[14] We assume, without deciding, that whether a variable was recognized as result-effective is a question of fact. *See Graham v. John Deere Co. of Kan. City*, 383 U.S. 1, 17 (1966) (scope and content of the prior art are factual issues).

the disclosed ranges of temperature and PO_2. As we have concluded, temperature and PO_2 were recognized as result-effective variables, and "discovery of an optimum value of a result effective variable in a known process is ordinarily within the skill of the art." *In re Boesch*, 617 F.2d 272, 276 (CCPA 1980). The record here presents such an ordinary case.

The ranges disclosed in the prior art overlapped with those of claim 1. The temperature range disclosed in the '732 publication for the preparation of FDCA was 50–250°C, most preferentially about 50–160°C. The full range fully encompasses claim 1's temperature range of between 140°C and 200°C, and the preferred range overlaps it. For pressure, the '732 publication taught an air pressure corresponding to a PO_2 of 14.5 bars, somewhat higher than the 1–10 bars recited in claim 1. But RU '177 disclosed appropriate air pressures corresponding to a PO_2 range of 2.1–10.5 bars for the production of FDCA, substantially overlapping with the claimed range, and the '318 publication disclosed preferred air pressures corresponding to a PO_2 of 2.17–7.24 bars. The prior art thus disclosed temperature and PO_2 ranges which overlapped with those claimed.

Claims 2–5 fare no differently from claim 1, as each of these claims adds limitations taught by the '732 publication. Claims 2–5 depend either directly or indirectly from claim 1. Claim 2 limits the reactant to HMF, esters thereof, and mixtures of the two. '921 patent col. 8 ll. 7–10. Claim 3 recites a catalyst with an additional metal, *id.* col. 8 ll. 11–12, and claim 4 requires that additional metal to be zirconium or cerium, *id.* col. 8 ll. 60–61. Claim 5 narrows the temperature range to between 160°C and 190°C. *Id.* col. 8 ll. 62–63. The '732 publication disclosed each of the added limitations of claims 2–4: HMF as a reactant, and a Co/Mn/Br catalyst optionally including zirconium. And the '732 publication's broad 50–250°C range fully encompasses the 160–190°C range of

claim 5, and the '732 publication's preferred range of 50–160°C abuts it. Thus, with respect to differences with the prior art, claims 2–5 are not meaningfully distinguished from claim 1.

As Synvina emphasizes, the Board found that a person of ordinary skill would not have been motivated to optimize the temperatures and pressures disclosed in the '732 publication given the teachings of RU '177 and the '318 publication. *See Decision*, slip op. at 17–22. This finding, however, was premised on the Board's erroneous determination that temperature and PO_2 were not well-understood result-effective variables. Consequently, the Board did not consider the "normal desire of scientists or artisans to improve upon what is already generally known," which "provides the motivation to determine where in a disclosed set of . . . ranges is the optimum combination." *Peterson*, 315 F.3d at 1330; *see also, e.g.*, *Applied Materials*, 692 F.3d at 1295. That motivation was sufficient for a skilled artisan to adjust result-effective parameters like PO_2 and temperature to values within the ranges disclosed in the asserted references that each concern the same basic oxidation reaction.

Thus, DuPont demonstrated that the prior art as a whole—three references each disclosing the same oxidation reaction of HMF or an HMF derivative to FDCA—taught the claimed reaction, as well as conditions either identical to or overlapping with those of claims 1–5. Under our precedent, this showing based on the prior art shifted the burden of production to the patent owner to demonstrate teaching away, unexpected results, or some other evidence of nonobviousness.[15] *E.g.*, *Galderma*, 737

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[15] We are not persuaded by Synvina's argument that our decision in *Genetics Institute* supports not applying the burden-shifting framework. That case involved disclosure of very broad ranges in the prior art—68,000

F.3d at 738; *Iron Grip Barbell*, 392 F.3d at 1322; *see Applied Materials*, 692 F.3d at 1298 ("Evidence that the variables interacted in an unpredictable or unexpected way could render the combination nonobvious . . . ."). Furanix and Synvina have failed to do so.

Furanix did not present evidence that the prior art taught away from the claimed invention, but did argue that objective evidence of nonobviousness supported patentability. However, we conclude that substantial evidence supports the Board's findings that Furanix failed to establish unexpected results, satisfaction of a long-felt need, or copying, and thus hold that the objective evidence presented by the patent owner does not outweigh the strong case of obviousness based on the prior art.

First, we address evidence of unexpected results, which was the primary focus of the Board. The Board found that Furanix did not establish unexpected results or criticality for the claimed temperature range. *Decision*, slip op. at 30. Synvina does not argue on appeal that the Board's findings lack substantial evidence, but does argue that its objective evidence "is quite robust and deserving of further evaluation." Appellee Br. 48. We disagree.

The Board found that Furanix's objective evidence "tends to show" that the claimed temperature range may lead to higher FDCA yields than the '732 publication. *Decision*, slip op. at 29. Specifically, the Board observed that the '921 patent specification disclosed an experiment where HMF was oxidized to FDCA at 78.08% yield, which is higher than the maximum yield of 58.8% reported in

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variants of a protein made up of 2,332 amino acids—that did not invite routine optimization. 655 F.3d at 1306. In contrast, this case presents "not especially broad" ranges of temperature and pressure. *Peterson*, 315 F.3d at 1330 n.1.

the '732 publication and is also higher than highest theoretical yield indicated by a different publication. *Id.* The Board also found, however, that it could not rule out other possible explanations for the higher yield than the claimed temperature range, as other reaction conditions such as catalyst concentration and reaction time, which may affect FDCA yields, were not the same in the '732 publication and the '921 patent. *Id.* Perhaps more importantly, the Board found that only a single pressure of 20 bars (4.2 bars PO_2) was tested in the experiments disclosed in table 1, so any unexpected results demonstrated by Furanix were not commensurate with the scope of the claims. *Id.* at 30 (citing *Peterson*, 315 F.3d at 1331 (affirming finding by the Board that unexpected results commensurate in scope with claimed range of 1–3% were not shown where unexpected results were only associated with 2%)).[16]

On appeal, Synvina does not address these shortcomings in its objective evidence. We therefore conclude that substantial evidence supports the Board's determination

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[16] While the specification of the '921 patent discusses other experiments conducted at different pressures in tables 2 and 3, '921 patent col. 6 l. 50–col. 7 l. 12, Synvina does not argue that these experiments achieved unexpected results. Table 2 included data from "comparative experiments" conducted under a prior art process oxidizing AMF at a pressure of 30 bars air (6.3 bars PO_2), but these experiments achieved lower FDCA yields of 23.48% and 29.05%, respectively. *Id.* col. 6 ll. 50–62, Table 2. Table 3 reported the oxidation of 5MF at 50 bars air (10.5 bars PO_2) and FDCA yields of 42.62% and 39.94%, respectively. *Id.* col. 6 l. 66–col. 7 l. 12, Table 3. In the prior art, RU '177 disclosed appropriate pressures as high as 50 bars air and yields as high as 36% for the oxidation of 5MF to FDCA. J.A. 2439–40.

that Furanix did not establish unexpected results or criticality commensurate in scope with the claims. *Accord Aller*, 220 F.2d at 457, 459 (finding no criticality where claimed conditions allegedly contributed to roughly 20 percentage point improvement in yield).

Furanix also alleged evidence of a long-felt need for a commercially viable process for making FDCA. *Decision*, slip op. at 31. The Board agreed that there was a long-felt need, but found that the evidence did not show how the process disclosed in the '921 patent solved that need, as the patent only reported laboratory-scale, not commercial-scale, experiments. *Id.* at 31–32. As with unexpected results, on appeal Synvina does not argue that the Board's finding lacks substantial evidence, nor does it explain how the '921 patent's lab results would scale to industrial use. Synvina's conclusory argument that lab results suffice to show satisfaction of the long-felt need is not sufficient to justify overturning the Board's contrary finding.

Finally, Furanix argued that DuPont and ADM copied its process by filing a patent application including examples of the oxidation of HMF under conditions similar to those in the '921 patent. *Id.* at 32. DuPont responded that the examples were based on other prior work done elsewhere. *Id.* The Board determined that a single example in a patent application was not sufficient evidence to establish copying. *Id.* On appeal, Synvina points to the patent application and DuPont's recently constructed plant, along with its purported operating ranges that DuPont relies on for standing, as evidence of copying.

Even considering the now-operating plant, we are not persuaded by Synvina's evidence of copying. Synvina has not alleged any direct evidence of copying, and the prior art disclosed the same reaction as the '921 patent and identical or overlapping reaction conditions. Where the prior art is so close, it has not been shown that DuPont

copied the '921 patent rather than the other references within the prior art. *See Wyers v. Master Lock Co.*, 616 F.3d 1231, 1246 (Fed. Cir. 2010) ("[C]opying requires evidence of efforts to replicate a specific product . . . ."). Thus, as with the other evidence of nonobviousness, we conclude that substantial evidence supports the Board's findings.

At bottom, this case involves a strong case of obviousness based on very close prior art and weak evidence of nonobviousness. We conclude that the Board therefore erred in not concluding that claims 1–5 would have been obvious at the time of the claimed invention.

2. Claims 7–9

Claims 7–9 recite the same oxidation reaction as claim 1 with the added limitation of esterifying the FDCA product. The esterification of FDCA was known at the time of the invention, as acknowledged in the '921 patent, col. 5 ll. 42–65. The Board found that the two additional references relevant to claims 7–9, Lewkowski and Oae, also disclosed the esterification of FDCA. *Decision*, slip op. at 10–11. Synvina does not argue that claims 7–9 are separately patentable from claims 1–5. *See* Appellee Br. 12 ("The Board's determination that those claims are patentable is supported by the same substantial evidence as claims 1–5."); Appellee Br. 40 (same). As we have concluded that claims 1–5 would have been obvious at the time of the invention, we hold the same for claims 7–9.

CONCLUSION

We have considered Synvina's remaining arguments but are not persuaded.[17] For the foregoing reasons, we

[17] We do not address DuPont's claim construction argument, as resolving it is unnecessary to our decision.

reverse the Board's decision with respect to claims 1–5 and 7–9.

REVERSED