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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

E. I. DU PONT DE NEMOURS AND COMPANY AND
ARCHER-DANIELS-MIDLAND COMPANY,
Petitioners,

v.

FURANIX TECHNOLOGIES B.V.,
Patent Owner.

Case IPR2015-01838
Patent 8,865,921 B2

Before TONI R. SCHEINER, SHERIDAN K. SNEDDEN and CHRISTOPHER G. PAULRAJ, *Administrative Patent Judges.*

PAULRAJ, *Administrative Patent Judge.*

FINAL WRITTEN DECISION
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

E. I. du Pont de Nemours and Company and Archer-Daniels-Midland Company (collectively, "Petitioners") filed a Petition (Paper 1, "Pet."), requesting institution of an *inter partes* review of claims 1–10 of U.S. Patent No. 8,865,921 B2 (Ex. 1001, "the '921 Patent"). Furanix Technologies B.V. ("Patent Owner") did not file a Preliminary Response. We have jurisdiction under 35 U.S.C. § 314, which provides that an *inter partes* review may not be instituted "unless . . . there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition." We determined that the information presented in the Petition demonstrated that there was a reasonable likelihood that Petitioners would prevail in challenging claims 1–5 and 7–9 as unpatentable under 35 U.S.C. § 103(a). Pursuant to 35 U.S.C. § 314, the Board instituted trial on March 9, 2016, as to those claims of the '977 Patent. Paper 10 ("Institution Decision"; "Inst. Dec."). We denied Petitioners' request for rehearing of our decision to deny institution as to the patentability challenge for claims 6 and 10. Paper 20.

Following our institution, Patent Owner filed a Response to the Petition. Paper 23 ("PO Resp."). Petitioners filed a Reply to Patent Owner's Response. Paper 29 ("Reply"). An oral hearing was held on November 16, 2016. The transcript of the hearing has been entered into the record. Paper 42 ("Tr.").

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73. Based on the record before us, we conclude that Petitioners have not demonstrated by a preponderance of the evidence that claims 1–5 and 7–9 of the ’921 Patent are unpatentable based on the obviousness challenges presented in the Petition.

A. Related Proceedings.

The parties have not identified any separate related matters under 42 C.F.R. § 42.8(b)(2). Pet. 1; Paper 5, 1.

B. The ’921 Patent (Ex. 1001)

The ’921 patent issued on October 21, 2014, and claims priority to a provisional application filed on October 7, 2009. *See* Ex. 1001, Title Page. It names Cesar Muñoz De Diego, Matheus Adrianus Dam, and Gerardus Johannes Maria Gruter as the inventors. *Id.*

The ’921 patent relates generally to methods for preparing 2, 5-furan dicarboxylic acid (FDCA), or a dialkyl ester of FDCA, by contacting 5-hydroxymethylfurfural (HMF), and/or derivatives thereof, with an oxygen-containing gas in the presence of oxidation catalysts comprising cobalt (Co), manganese (Mn), and bromine (Br) (*i.e.*, a Co/Mn/Br catalyst), and an acetic acid solvent at elevated temperatures. *Id.*, Abstract, 1:18–26, 2:39–45. The ’921 patent states that “FDCA can be produced in particular from esters of HMF, such as for example 5-acetoxymethylfurfural (AMF) or a mixture of one or more of these compounds with HMF, such as for example from a mixture of AMF and HMF.” *Id.* at 1:21–24. The ’921 patent further discusses the use of FDCA obtained according to the process described therein to prepare a dialkyl ester of 2,5-dicarboxylic acid by the reaction of FDCA with a C_1–C_5 alkyl alcohol. *Id.* at 5:20–41. The ’921 patent acknowledges that the esterification of FDCA was known in the prior art. *Id.* at 5:42–58.

According to the ’921 patent, FDCA has been identified as a priority chemical for establishing a “green” chemistry industry, but no commercial process exists for its production. *Id.* at 1:34–38. The specification states that FDCA, a furan derivative, is often synthesized in the laboratory from HMF obtained from carbohydrate containing sources such as glucose, fructose, sucrose, and starch. *Id.* at 1:30–43. The derivatives of HMF are known to be potential and versatile fuel components and precursors for the production of plastics. *Id.* at 1:44–46. The specification identifies prior art processes for the oxidation of HMF to FDCA with a Co/Mn/Br catalyst at temperatures ranging from 50 to 125ºC, which resulted in low reactivity or yield loss. *Id.* at 1:48–67, 2:1–35. The ’921 patent seeks to improve prior art yields by controlling the temperature and/or pressure under which the oxidation reaction occurs. *Id.* at 4:34–61.

In particular, the ’921 patent specification explains that “[t]he pressure in a commercial oxidation process may vary within wide ranges,” and “is determined by the solvent (e.g., acetic acid) pressure at a certain temperature.” *Id.* at 4:34–39. Moreover, the pressure is preferably selected to maintain the solvent in the liquid phase, which “means that pressures between 5 and 100 bar can be used with a preference for pressures between 10 and 80 bar.” *Id.* at 4:39–43. The oxidant can be an oxygen-containing gas, such as air, which “can be continuously fed to and removed from the reactor,” in which case “the oxygen partial pressure will suitably be between 1 and 30 bar or more preferably between 1 and 10 bar.” *Id.* at 4:43–46, 51–55. Conversely, all of the oxygen-containing gas can be supplied at the start of the reaction, but this will require a significantly higher pressure. *Id.* at 4:45–51. The specification further explains 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.* at 4:56–58. The specification notes that “[g]ood results” were achieved at about 180°C, but cautions that “[t]emperatures higher than 180° C may lead to decarboxylation and to other degradation products.” *Id.* at 4:58–61.

The ’921 patent includes working examples describing experiments in which the oxidation reaction was carried out with a Co/Mn/Br catalyst at an air pressure ranging from 20–60 bars and temperatures ranging from 100 to 220°C. *Id.* at 6:8–11. More particularly, Example 1 describes the oxidation of HMF and/or AMF at 180°C for 1 hour with 20 bar air pressure, which resulted in FDCA yields of up to 78.08%. *Id.* at 6:34–46, Table 1. Example 2 provides a comparative example in which AMF oxidation was conducted at 100°C and 30 bar for 2 hours, showing that FDCA yields under those conditions were lower than the results obtained at higher temperature. *Id.* at 6:50–62, Table 2.

C. Illustrative Claims

Claims 1–5 and 7–6 are challenged in this *inter partes* review. Independent claim 1 is illustrative, and reproduced below:

> 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.

Independent claim 7 is directed to the preparation of a dialkyl ester of FDCA, and additionally recites the step of "esterifying the thus obtained product."

D. Patentability Challenges

The following patentability challenges are at issue in this proceeding:

References	**Basis**	**Claims challenged**
The '732 publication,[1] RU '177,[2] and the '318 application[3]	§ 103(a)	1–5
The '732 publication, Lewkowski,[4] Oae,[5] RU '177, and the '318 application	§ 103(a)	7–9

In addition to the teachings of the references, Petitioners rely upon the Declarations of Kevin J. Martin, Ph.D. (Ex. 1009; Ex. 1028) in support of these challenges.

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[1] Grushin et al., WO 01/72732 A2, published Oct. 4, 2001 (Ex. 1002).

[2] Slavinskaya et al., USSR Patent RU-448177A1, published Oct. 30, 1974 (Ex. 1007, with certified English translation).

[3] Lilga et al., US 2008/0103318 A1, published May 1, 2008 (Ex. 1008).

[4] Lewkowski, *Synthesis, Chemistry and Applications of 5-Hydroxymethylfurfural and its Derivatives*, ARKIVOC 2001 (i) 17–54, Published Online on Aug. 8, 2001 (Ex. 1005).

[5] Oae et al., *A Study of the Acid Dissociation of Furan- and Thiophenedicarboxylic Acids and of the Alkaline Hydrolysis of Their Methyl Esters*, SOC. JPN. 1965, 38, Aug. 1965, at 1247 (EX. 1006).

II. DISCUSSION

A. Claim Construction

We interpret claims of an unexpired patent using the “broadest reasonable construction in light of the specification of the patent in which [they] appear[].” 37 C.F.R. § 42.100(b); *Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131, 2146 (2016). Under the broadest reasonable construction standard, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art at the time of the invention. *In re Translogic Tech., Inc*., 504 F.3d 1249, 1257 (Fed. Cir. 2007). “Absent claim language carrying a narrow meaning, the PTO should only limit the claim based on the specification . . . when [it] expressly disclaim[s] the broader definition.” *In re Bigio*, 381 F.3d 1320, 1325 (Fed Cir. 2004). “Although an inventor is indeed free to define the specific terms used to describe his or her invention, this must be done with reasonable clarity, deliberateness, and precision.” *In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994).

We determine that no explicit construction of any claim term is necessary to resolve the issues in this case. *See, e.g., Wellman, Inc. v. Eastman Chem. Co.*, 642 F.3d 1355, 1361 (Fed. Cir. 2011) (“[C]laim terms need only be construed ‘to the extent necessary to resolve the controversy.’”) (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)).

B. Prior Art Relied Upon

Petitioners rely upon the following prior art in their challenges.

1. *The ’732 publication (Ex. 1002)*

The ’732 publication describes the oxidation of HMF to FDCA, and the subsequent decarbonylation to unsubstituted furan. Ex. 1002, Title, 2:17–20.[6] The catalyst used for the oxidation process described in the ’732 publication “can be comprised of Co and/or Mn, and Br, and optionally [zirconium,] Zr.” *Id.* at 6:22–24. Acetic acid is identified as a preferred solvent because FDCA is insoluble in it, thereby facilitating purification. *Id.* at 9:14–21.

The ’732 publication explains further that “[f]or preparation of diacid, the preferred temperatures are about 50^o to 250^oC, most preferentially about 50^o to 160^oC,” and “[t]he corresponding pressure is such to keep the solvent mostly in the liquid phase.” *Id.* at 8:2–5. The ’732 publication discloses examples wherein “[p]lacing HMF in reactors with acetic acid and catalyst metals and having them react with air at 1000 psi (7 MPa) gave good yields of FD[C]A.” *Id.* at 16:3–4. In Examples 38–40, “the temperature was staged – initially it was held at 75°C for 2 hrs. and then raised to 150°C for two hrs,” which “gave higher yields.” *Id.* at 16:13–15, Table 4.

The ’732 publication is identified as prior art in the background section of the ’921 patent, which indicates that “[t]he maximum FDCA yield reported is 59%, obtained at 105° C.” Ex. 1001, 1:48–50.

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[6] The ’732 publication uses the acronym “FDA” for 2,5-furan dicarboxylic acid. For the sake of consistency, we will refer to the compound as FDCA. We also refer herein to the page numbers added to the very bottom of the exhibit (e.g., “Petitioners’ Exhibit 1002, Page 2 of 23”).

2. RU ’177 (Ex. 1007)

RU ’177 is an “Inventor’s Certificate” issued by the former Union of Soviet Socialist Republics (USSR), which also teaches a method for producing FDCA. Ex. 1007, Title. Specifically, RU ’177 claims a process of producing FDCA using air oxidation wherein “5-methylfurfural [5MF] is subject to oxidation and mixed valance metal salts, such as a mixture of cobalt acetate and manganese acetate, as well as bromine-containing compounds, such as ammonium bromide, in the aliphatic carboxylic acid solution are used as a catalyst.” *Id.* at 2, col. 4 (claim 1). RU ’177 also includes a claim specifying that the “oxidation is conducted at the temperature of 115–140°C and air pressure of 10–50 atm.” *Id.* at 2, col. 4 (claim 2). RU ’177 further discloses that oxidation is “typically conducted under 115-140°C and air pressure of 10-15 atm.” *Id.* at 1, col. 1. In Example 1 of RU ’177, 5MF was reacted at 118°C and 20 atm of pressure (4.26 bar pO_2) for 4.5 hours and then the temperature was increased to 130°C and pressure increased to 30 atm (6.38 bar pO_2). *Id.* at 2, col. 3.

RU ’177 states the method disclosed therein has a number of advantages, i.e., “it utilizes readily available and inexpensive reagents as the initial compound and catalysts [and] the method is a one-step process.” *Id.* at 1, col. 2.

3. The ’318 application (Ex. 1008)

The ’318 application also relates to a method of oxidizing HMF to produce various derivatives, including FDCA. Ex. 1008 ¶ 3. More specifically, the ’318 application teaches that “[t]he starting material comprising HMF is provided into a reactor and at least one of air or O_2 is provided as oxidant.” *Id.* ¶ 50. The ’318 application indicates that, depending upon the desired reaction rate, the pressure utilized may range from atmospheric pressure to the pressure rating of the equipment, and "[a] preferred pressure can typically be in the range of 150-500 psi." *Id.* "Similarly an appropriate reaction temperature can be from about 50° C to about 200° C, with a preferred range of from 100° C through about 160° C." *Id.*

The '318 application states that "under particular reaction conditions, HMF conversions of 100% were achieved with selectivity to FDCA as high as 98% relative to all other reaction products, intermediates and byproducts." *Id.* ¶ 55. In Example 1, 98% FDCA selectivity was achieved using a Pt/ZrO_2 catalyst under conditions of 150 psi pressure and 100°C temperature. *Id.* ¶¶ 67–68.

4. Lewkowski (Ex. 1005)

Lewkowski discusses the methods of synthesis of FDCA, and its chemistry and application. Ex. 1005, 17. Lewkowski states "[t]he synthesis of diethyl ester and dimethyl ester . . . have been reported." *Id.* at 44. Lewkowski cites Oae (Ex. 1006) for the synthesis process of dimethyl ester. *Id.* Lewkowski discloses that the diethyl ester of FDCA has "a strong anaesthetic action similar to cocaine," and that another ester form of FDCA—dicalcium 2,5-furandicarboxylate—was shown to have antibacterial activity. *Id.* at 45.

5. Oae (Ex. 1006)

Oae relates to the acid dissociation of furandicarboxylic acids and the alkaline hydrolysis of their methyl esters. Ex 1006, 1247. Specifically, Oae states that dimethyl esters of FDCA were synthesized in the following manner: "Dicarboxylic acid (0.064 mol.) was refluxed with 10 ml. of anhydrous methanol in a benzene solution with one or two drops of concentrated sulfuric acid for several hours," and "[a]fter the removal of the excess methanol, the residual dimethyl ester was recrystallized from a suitable solvent several times to give the correct melting point." *Id.* at 1249. This method yielded 68.7% dimethyl 2,5-furandicarboxylate. *Id.*

6. *Partenheimer (Ex. 1003)*[7]

Partenheimer is cited and discussed in the background section of the '921 patent. Ex. 1001, 1:55–2:6. Partenheimer describes synthesis of 2,5-diformylfuran and FDCA by catalytic air-oxidation of HMF. Ex. 1003, 102 (Title). Specifically, Partenheimer teaches synthesis of FDCA by contacting HMF in the presence of Co/Mn/Br catalysts Co, and with an air pressure of 70 bar at temperatures up to 125° C. *Id.* at 105 (Table 3).

According to Partenheimer, the advantages of the oxidation process described therein are 1) "that the catalyst is composed of inexpensive, simple metal acetate salts and a source of ionic bromide (NaBr, HBr, etc.),"

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[7] Partenheimer et al., *Synthesis of 2, 5-Diformylfuran and Furan-2, 5-Dicarboxylic Acid by Catalytic Air-Oxidation of 5-Hydroxymethylfurfural. Unexpectedly Selective Aerobic Oxidation of Benzyl Alcohol to Benzaldehyde with Metal/Bromide Catalysts*, 343 ADV. SYNTH. CATAL. 102–111, Published Online on Feb. 6, 2001 (Ex. 1003) ("Partenheimer"). Although Partenheimer did not form the basis for the specific patentability challenges upon which we instituted trial, both Petitioners and Patent Owner have relied upon Partenheimer's teachings to support their respective arguments. *See* Pet. 15–16; PO Resp. 3, 8, 10, 20, 26–28; Reply 7, 10–12, 19. We, therefore, consider Partenheimer as relevant "background" art in our evaluation of Petitioners' patentability challenges. *See Ariosa Diagnostics v. Verinata Health, Inc.*, 805 F.3d 1359, 1365 (Fed. Cir. 2015) ("Art can legitimately serve to document the knowledge that skilled artisans would bring to bear in reading the prior art identified as producing obviousness.").

2) "[t]he reaction times are within a few hours at easily accessible temperatures," and 3) "[t]he acetic acid solvent is inexpensive and nearly all alcohols are highly soluble in it." *Id.* at 106. Partenheimer teaches that the reactions are performed at air pressure of 70 bar and cautions that "[t]he use of high pressures and the use of dioxygen/nitrogen mixtures is potentially explosive and dangerous," and "should be performed only with adequate barriers for protection." *Id.* at 110.

C. Level of Ordinary Skill in the Art

Petitioners' expert Dr. Martin opines that "one of ordinary skill in the art of oxidation of aromatic compounds, such as furan based compounds, is a person with a doctorate degree in chemistry and/or chemical engineering and having at least 5 years of experience in oxidation catalysis and chemical process development." Ex. 1009 ¶ 14. Patent Owner contends that a person of ordinary skill in the art ("POSA" or "skilled artisan") for the '921 patent would have had "at least a bachelor's degree in chemistry or chemical engineering, having worked in the field of chemical process development for at least five years and having experience in the preparation of furan compounds from biomass and in the catalysis of oxidation of furan compounds for a similar period." PO Resp. 14 (citing Ex. 2003 ¶ 44). In its Reply, Petitioners contend that Patent Owner's proposed level of skill in the art places too many limitations, "whereas Petitioner's hypothetical POSA – as defined by Dr. Martin – would have the knowledge and experience to understand that catalyst concentration is a result-effective variable that impacts yield." Reply 2 (citing Ex. 1028 ¶ 7).

Although we do not discern a significant difference between the qualifications for a skilled artisan proposed by the parties, we determine that Patent Owner's proposed level of skill in the art is more appropriate for our analysis. Specifically, we determine that a skilled artisan need not have a doctorate degree. Patent Owner's expert, Dr. Wayne P. Schammell, Ph.D., states that in his experience "individuals working in the field often have BS or MS degrees with relevant experience in the field." Ex. 2003 ¶ 44. At his deposition, Dr. Martin acknowledged that a chemist with a master's degree could be a skilled artisan "with appropriate experience," and that one with a bachelor's degree that focuses on organic chemistry and at least 10 years of experience could also be a skilled artisan. Ex. 1027, 112:21–114:1. We have also taken into account the level of skill in the art that is reflected in the prior art references themselves. *See Okajima v. Bourdeau*, 261 F.3d 1350, 135 (Fed. Cir. 2001). With regard to Petitioners' contention as to whether a skilled artisan would have the knowledge and experience to understand whether a catalyst concentration is a result-effective variable (Reply 2), we determine that issue is more appropriately considered as part of the substance of the obviousness analysis rather than our determination of the appropriate skill level for the '921 patent.

D. Analysis of Petitioners' Patentability Challenges

Petitioners contend that claims 1–5 are obvious based on the teachings of the '732 publication in combination with RU '177 and the '318 application. Pet. 27–40. Petitioners additionally contend that claims 7–9 are obvious over the combination of the '732 publication, RU '177, and the '318 application in further view of Lewkowski and Oae. *Id.* at 45–49.

Independent claim 1 requires the preparation of FDCA by contacting a feed comprising HMF, or certain derivatives of HMF, with an oxygen-containing gas in the presence of a Co/Mn/Br oxidation catalyst, and an acetic acid-based solvent or solvent mixture, at a temperature between 140°C and 200°C, and at an oxygen partial pressure (pO_2) of 1 to 10 bar. Ex. 1001, 7:60–8:6. Independent claim 7 recites the same process of claim 1, and further recites the additional step of "esterifying the thus obtained product" in order to produce a dialkyl ester of FDCA. *Id.* at 9:1–14. We focus our analysis on these independent claims.

In our Institution Decision, we determined that Petitioners demonstrated a reasonable likelihood of prevailing with respect to these obviousness challenges based on the preliminary record at the time and instituted trial on that basis. Inst. Dec. 13–15, 18–19. We have now reconsidered the arguments and evidence presented with the Petition, along with the additional arguments and evidence presented with Patent Owner's Response and Petitioners' Reply, under the preponderance of the evidence standard applicable to Final Written Decisions in an *inter partes* review. 35 U.S.C. § 316(e).

As an initial matter, we comment on Petitioners' attempts to apply the "prima facie" burden-shifting framework typically applied during patent examination to argue obviousness in this proceeding. *See, e.g.*, Pet. 8 ("Thus, the claims of the '921 patent are *prima facie* rendered obvious in view of the '732 publication because there is no evidence that reducing the oxygen partial pressure by 4.5 bar[] is critical to the methods or process of oxidizing HMF to FDCA."); *id.* at 50 (asserting that "[a] *prima facie* case of obviousness exists where the claimed ranges and prior art ranges do not overlap but are close enough that one skilled in the art would have expected them to have the same properties") (citing MPEP § 2144.05); Reply 9 (arguing that "[t]his overlap [in temperature] alone supports a finding of a *prima facie* case of obviousness."); *id.* at 14–15 ("Because the claimed ranges 'overlap or lie inside ranges disclosed by the prior art,' a *prima facie* case of obviousness exists."). Based on the prior art's disclosure of broader or overlapping ranges, Petitioners seek to shift the burden to Patent Owner to rebut their alleged prima facie case by showing "criticality" with the claimed ranges. *See, e.g.,* Reply 9, 13, 21–23. The Federal Circuit has stated, however, that such a "burden-shifting framework does not apply in the adjudicatory context of an [*inter partes* review]." *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1375 (Fed. Cir. 2016). Rather, "[i]n an *inter partes* review, the burden of persuasion is on the petitioner to prove 'unpatentability by a preponderance of the evidence,' 35 U.S.C. § 316(e), and that burden never shifts to the patentee." *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015) (citation omitted).

Taking Petitioners' burden of persuasion into account, we find that the evidence fails to show it would have been obvious to adjust both the temperature and pO_2 in the processes taught by the prior art to within the claimed ranges as a matter of routine optimization. We have also considered Patent Owner's "objective evidence" concerning unexpected results, satisfaction of a long-felt but unmet need, and copying, but find that evidence to be less probative in supporting a conclusion of non-obviousness. Nonetheless, based upon our consideration of the record as a whole, we determine that Petitioners have not established the unpatentability of claims

1–5 and 7–9 by a preponderance of the evidence. We address these issues separately in further detail below.

1. *Optimization of Temperature to Between 140° and 200°C and Oxygen Partial Pressure to Between 1 and 10 Bar*

Although the prior art disclosed processes with broader or overlapping temperature or pressure ranges, 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 as required by the challenged claims of the ’921 patent. Petitioners, therefore, rely upon an “optimization” rationale to assert that the claimed invention would have been obvious. *See, e.g.*, Pet. 9 (“[V]ariations in temperature and pressure are nothing more than the optimization of oxidation conditions explicitly suggested by the ’732 publication . . . Conducting routine experimentation to determine optimal or workable ranges that produce expected results is suggested to one of ordinary skill in the art by the ’732 publication.”).

It is well-established 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). However, the parameter to be optimized must have been *recognized* by those skilled in the art to be a “result-effective variable.” *In re Antonie*, 559 F.2d 618, 620 (CCPA 1977). “While the absence of any disclosure regarding the relationship between the variable and the affected property may preclude a finding that the variable is result-effective, the prior art need not provide the exact method of optimization for the variable to be result-effective." *In re Applied Materials, Inc.*, 692 F.3d 1289, 1297 (Fed. Cir. 2012). Rather, "[a] recognition in the prior art that a property is affected by the variable is sufficient to find the variable result-effective." *Id.* Moreover, where multiple result-effective variables are combined, "[e]vidence that the variables interacted in an unpredictable or unexpected way could render the combination nonobvious." *Id.* at 1298 (citing *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007)). Applying these principles, we find that Petitioners have not demonstrated that it would have been a matter of routine experimentation to optimize the reaction temperature and pO_2 as result-effective variables.

Petitioners contend that "the '732 publication suggested to a person of ordinary skill in the art to vary residence time, temperature and pressure to within the claimed ranges, in order to maximize yield." Pet. 9. Petitioners assert that the '732 publication discloses oxidation of HMF to FDCA with Co/Mn/Br or Co/Mn/Zr/Br catalysts at a temperature range of about 50° to 250°C, most preferentially about 50° to 160°C, with a corresponding pressure that keeps the acetic acid solvent mainly in the liquid phase. *Id.* at 30–31 (citing Ex. 1002, 7:2–5, 4:37–41, 15:7–9; Ex. 1009 ¶¶ 20, 86). In particular, Petitioners point to the general disclosure that "[f]or preparation of diacid, the preferred temperatures are about 50° to 250°C, most preferentially about 50° to 160°C," and that "*[t]he corresponding pressure is such to keep the solvent mostly in the liquid phase*." *Id.* at 9 (citing Ex. 1002, 7:2–7). Petitioners also point to the examples in the '732 publication showing reactions of HMF to FDCA at 150°C and at an air pressure of 1000 psi. *Id.* at 31 (citing Ex. 1002, 15–16; Ex. 1009 ¶ 20). As noted by Petitioners, 1000 psi air pressure converts to approximately 14.5 bar pO_2

when calculated using ~21% oxygen in air, and to 13.8 bar pO_2 when calculated using 20% oxygen in air. *Id.* at 33–34. Petitioners contend that there is no evidence of a "patentable distinction (i.e., criticality) between the claimed pO_2 value 1–10 bar (properly construed up to 10.5 bar) and the prior art 13.8 bar pO_2 practiced in the '732 publication, especially since the '732 publication relies on reaction pressures for the same reason proffered by the '921 patent," i.e., "pressure of the reaction mixture is preferably selected such that the solvent is mainly in the liquid phase." *Id.* at 34 (citing Ex. 1001, 4:39–41).

Patent Owner argues that "[t]he cited prior art describes inefficient, non-commercially viable processes and does not teach or suggest the combination of temperature, oxygen partial pressure and catalyst operating parameters of the '921 patent's invention." PO Resp. 1. With respect to the '732 publication in particular, Patent Owner asserts that "the '732 publication's process is done at higher pressure and the oxidation of HMF is outside the temperature range recited in" the claims. *Id.* at 15. We are persuaded by Patent Owner's arguments and supporting evidence. Although the '732 publication teaches broadly a preferred temperature range of about 50° to 250°C (most preferentially about 50° to 160°C), it does not suggest specifically keeping the temperature within the narrower range recited in claims 1 and 7 (between 140 and 200°C) while also maintaining pO_2 between 1 and 10 bar. The '732 publication also teaches that "[t]he preferred time of the reaction is determined by the temperature, pressure and catalyst concentration such that a maximum yield of diacid is obtained." Ex. 1002, 7:5–7. The reference also states that Table 4 "illustrates that increasing catalyst concentrations at a given temperature and time, nearly always increased the [FDCA] yield." *Id.* at 15:9–11. However, contrary to Petitioners' optimization rationale, we find nothing in the '732 publication or the other cited prior art to suggest that adjusting both reaction temperature and pO_2 in the process could have predictably affected FDCA yields.

With respect to the claimed oxygen partial pressure range, we find that the disclosure in the '732 publication that "corresponding pressure is such to keep the solvent mostly in the liquid phase" (*see* Ex. 1002, 7:4–5) would not have led the skilled artisan to optimize pO_2 to within the claimed range because it relates to the *total* pressure in the reaction chamber rather than the partial pressure of oxygen, as Dr. Martin confirmed during his deposition. *See* Ex. 1027 (Martin Depo.), 114:6–115:1. Moreover, the examples of the '732 publication used a pressure with a significantly higher pO_2 (i.e., 14.5 bar), suggesting that an overall pressure sufficient to keep the solvent in the liquid phase would not always fall within the claimed pO_2 range of 1 to 10 bar.

Likewise, while the '921 patent also states that "[t]he pressure of the reaction mixture is preferably selected such that the solvent is mainly in the liquid phase," it further states that "[i]n practice this means that pressures between 5 and 100 bar can be used with a preference for pressures between 10 and 80 bar." Ex. 1001, 4:39–43. The '921 patent also indicates that "[i]n the case of continuously feeding and removing the oxidant gas to and from the reactor, the oxygen partial pressure will be suitably between 1 and 30 bar or more preferably between 1 and 10 bar." *Id.* at 4:51–55. As such, we find that the desire to keep the solvent in the liquid phase that is common to both the '732 publication and the '921 patent would not have necessarily required a pO_2 between 1 and 10 bar.

Petitioners further rely upon RU ’177’s disclosure regarding the oxidation of an HMF derivative—5MF—to FDCA in the presence of acetic acid and a Co/Mn/Br catalyst, conducted under 115–140°C and air pressure of 10–15 atm. Pet. 35 (citing Ex. 1007, 1). Petitioners assert that the oxidation conducted according to RU ’177 was at pressures that correlated to about 4.26 bar and 6.38 bar pO_2, which fell within the claimed range of 1–10 bar, albeit at lower temperatures. *Id.* at 36. Petitioners further rely upon the ’318 application’s teaching of conducting catalytic oxidation of HMF at a preferred temperature of “from 100°C[] through about 160°C” and a pressure of 150–500 psi. *Id.* at 35 (citing Ex. 1008, ¶ 50). Thus, Petitioners assert that the skilled artisan “would have been motivated and enabled to lower the pO_2 to 1-10 bars based on RU ’177 and ’318, and based on standard cost reduction considerations.” *Id.* (citing Ex. 1009 ¶ 96).

We are unpersuaded by Petitioners’ reliance on RU ’177 and the ’318 application, and “standard cost reduction considerations,” as a reason to lower pO_2 to within the claimed range of 1–10 bar. Pet. 35 (citing Ex. 1009 ¶ 96). Neither RU ’177 nor the ’318 application identify cost reduction or any other specific reason to keep the pO_2 lower than the 1000 psi pressure (~14.5 bar pO_2) used in examples of the ’732 publication. As support for his opinion that capital and operating costs can be saved using a lower pressure, Dr. Martin relies upon patents discussing the oxidation of xylene rather than the oxidation of HMF or its derivatives to FDCA. Ex. 1009 ¶ 66 (citing Ex. 1023 (U.S. Patent No. 4,792,621 (“the ’621 patent”)); Ex. 1025 (U.S. Patent No. 5,099,064(“the ’064 patent”))). Dr. Martin asserts that “[b]ecause the same solvent, catalyst and liquid phase environment are used [in] the ’621 patent, ’064 patent and the ’732 publication, there is a strong nexus between

HMF/AMF oxidations and the xylene oxidations in the art that pressure parameters for optimization of aromatic furan compounds are more directed." *Id.* Dr. Martin, however, acknowledged at his deposition that a skilled artisan would not take the parameters developed for xylene and apply them for the oxidation of HMF to FDCA. Ex. 1027, 68:12–22. Furthermore, any motivation to lower production costs by lowering the pressure would need to be balanced with the skilled artisan's expectation that increasing pO_2, thereby increasing the amount of oxygen in the process as a reactant, would have led to increased yields. Ex. 2003 ¶112.

Moreover, even if cost considerations were taken into account, RU '177 describes the production of FDCA from a different starting material (5MF) and produces a lower yield (23–36%) in comparison to at least some of the examples disclosed in the '732 publication using HMF as the starting material. Ex. 1007, 1, col. 2; Ex. 1002, 15–16. Petitioners have not adequately shown that the skilled artisan would have looked to reaction conditions disclosed for oxidizing 5MF when seeking to optimize the pO_2 in the '732 publication's process for oxidizing HMF. Although the '318 application discloses the oxidation of HMF to FDCA and produces a higher yield, it uses a different catalyst system, *i.e.*, platinum on a support material, and not the Co/Mn/Br catalyst system used in the '732 publication and the '921 patent. Ex. 1008 ¶¶ 69–70. As explained by Dr. Schammel, the fixed bed process taught by the '318 application would not have been considered commercially viable due to the use of an extremely diluted HMF feedstock and catalyst deactivation. Ex. 2003 ¶ 74. Furthermore, the process described in the '318 application uses a different solvent system that included water (Ex. 1008, Abstract; Ex. 2003 ¶ 73), and Petitioners acknowledge that a skilled artisan "would have known that the pressures used are a function of the solvent system." Reply 14 (citing Ex. 1009 ¶ 66). Accordingly, Petitioners have not demonstrated adequately that the skilled artisan would have considered the reaction conditions taught by the '318 application when optimizing pO_2 in a process using a Co/Mn/Br catalyst system with acetic acid as the solvent.

Additionally, with respect to the claimed temperature range, we do not find that either the generic temperature ranges or the specific reaction temperatures disclosed in the '732 publication would have led the skilled artisan to optimize the reaction temperature to within the claimed range of between 140 and 200°C. Although we recognize that the '732 publication discloses a broader "preferred" temperature range, and an overlapping "most preferential[]" range, for the preparation of the diacid, that general disclosure does not suggest that *any* temperature falling within those disclosed ranges is appropriate under all conditions for the oxidation of HMF to FDCA. Ex. 1002, 7:2–7. To the contrary, with the exception of the two-staged reactions discussed below, all the examples of the '732 publication use reaction temperatures that are lower than what is claimed. *Id.* at 15–16 (examples with temperatures of 100°C, 105°C, and 125°C). To support Petitioners' contention that temperature is a result-effective variable, Dr. Martin relies upon a comparison of certain examples in Table 4 of the '732 publication to assert that "three out of the four sets of runs with identical conditions (except temperature) show increasing FDCA yield with a temperature change from 100°C to 125°C." Ex. 1009 ¶43 (comparing examples 16 and 21, 17 and 22, 18 and 23, 19 and 24). As noted by Patent Owner, however, other examples in the '732 publication with otherwise identical conditions demonstrate that increasing the reaction temperature will *not* necessarily increase FDCA yield. PO Resp. 17–18 (comparing examples 20 and 25, 19 and 24, 17 and 35).[8]

Petitioners also rely upon examples 38–40 of the ’732 publication, which involve a two-staged reaction performed first at 75°C for two hours followed by 150°C for two hours as teaching oxidation at 150°C. Pet. 31; Ex. 1002, 16. As explained by Dr. Schammel, however, the skilled artisan would understand that after the first stage at 75°C for 2 hours, there is essentially no HMF remaining in the reaction. Ex. 2003 ¶ 5. As support, Dr. Schammel points to example 13, which indicates an HMF conversion rate of 99.7% after reaction at 75°C for two hours under similar reaction conditions to the first stage of example 38. *Id.*; Ex. 1002, 15. Dr. Martin also acknowledged that in example 38, after the first stage at 75°C for two hours, virtually all of the HMF (99.7%) has been converted to other compounds so that for the second stage at 150°C, the starting material is not HMF. Ex. 1027, 83:12–84:4. Even if there is a small amount of unconverted HMF remaining after the first reaction stage, there is nothing to suggest that the skilled artisan would have considered that residual amount to satisfy the claim requirement of a “feed” of HMF or any of the other

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[8] Indeed, the highest FDCA yield reported in Table 4 was for example 28 (58.8%), which was conducted at 105°C rather than the higher 125°C used for other examples in Table 4. Ex. 1002, 15. Although we recognize that example 28 involved a longer reaction time (12 hours) than the two hour reaction time used in the examples conducted at 125°C, Patent Owner points out that increased reaction time does not always lead to a higher FDCA yield. PO Resp. 19 (comparing examples 29 and 32, 31 and 34, which were also conducted at 105°C, and showing increased yields at 8 hours compared to 12 hours).

claimed starting compounds. As such, we do not consider the two-staged reaction examples of the ’732 publication to suggest reacting a feed of HMF or any other claimed starting compound at a temperature between 140°C and 200°C.

Petitioners further point to statements in Partenheimer, an article discussed in the background section of the ’921 patent, as suggesting that an increased yield would have been expected from increasing reaction temperature. Reply 7 (citing Ex. 1003, 105). Petitioners, however, selectively quote from Partenheimer and fail to provide the quoted statements in context. Specifically, Petitioners assert that Partenheimer indicates that “the conversion increases with temperature, *as expected*,” but that statement refers to a discussion about the formation of 2,5-diformulfuran (DFF) from HMF under reaction temperatures of 50 and 75°C rather than the conversion of HMF to FDCA under the higher reaction temperatures required by the claimed process of the ’921 patent. Reply 7; Ex. 1003, 104–105. Petitioners additionally assert that Partenheimer states that “[t]he yield increases . . . with temperature,” but that discussion is limited to comparing reaction temperatures of 100°C and 125°C, and does not disclose that temperatures over 125°C would further increase yield. Reply 7; Ex. 1003, 105. Rather, Partenheimer underscores the unpredictability of temperature on FDCA yields by noting that “one would expect that staging the temperature would increase yield,” but “[t]his was not observed . . . since staging the temperature from an initial value of 50 °C for 1 h and then 125 °C for 2 h gave no better results than the oxygenation at 125 °C for 3 h.” Ex. 1003, 105.

Accordingly, for the foregoing reasons, we find that Petitioners have failed to demonstrate 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.

2. Objective Evidence of Non-Obviousness

Patent Owner further contends that "even if there were a *prima facie* case of obviousness over the prior art, it is overcome by the very strong objective evidence of non-obviousness here, including unexpected results, satisfaction of a long-felt, but unmet need and copying by Petitioner[s]." PO Resp. 1–2. All objective evidence of non-obviousness (i.e., "secondary considerations") that is presented must be taken into account before reaching the ultimate conclusion of obviousness under 35 U.S.C. § 103. *See Apple Inc. v. Int'l Trade Comm'n*, 725 F.3d 1356, 1365 (Fed. Cir. 2013) ("[O]bjective evidence of secondary considerations . . . must be considered before determining whether the claimed invention would have been obvious to one of skill in the art at the time of invention."). "[T]he Board should give the objective indicia its proper weight and place in the obviousness analysis, and not treat objective indicia of nonobviousness as an afterthought." *Leo Pharmaceutical Products, Ltd. v. Rea*, 726 F.3d 1346, 1358 (Fed. Cir. 2013).

a. Unexpected Results/Criticality

Patent Owner relies upon the data in Table 1 of the '921 patent as well as recent testing performed specifically for this *inter partes* review proceeding to purportedly show the criticality of the claimed temperature range in producing unexpectedly high FDCA yields of almost 80%. PO Resp. 2.

In order to demonstrate "improved performance in a range that is within or overlaps with a range disclosed in the prior art," it must be "show[n] that the [claimed] range is *critical*, generally by showing that the claimed range achieves unexpected results relative to the prior art range." *In re Woodruff*, 919 F.2d 1575, 1578 (Fed.Cir.1990). "Only if the 'results of optimizing a variable' are 'unexpectedly good' can a patent be obtained for the claimed critical range." *In re Geisler*, 116 F.3d 1465, 1470 (Fed. Cir. 1997) (citation omitted). The comparison required to show unexpected results must be a comparison of the results of the claimed invention to the results of the closest prior art. *In re Baxter Travenol Labs.*, 952 F.2d 388, 392 (Fed. Cir. 1991) ("[W]hen unexpected results are used as evidence of nonobviousness, the results must be shown to be unexpected compared with the closest prior art."). In assessing unexpected results, "'differences in degree' of a known and expected property are not as persuasive in rebutting obviousness as differences in 'kind'—i.e., a new property dissimilar to the known property." *Bristol-Myers Squibb Co. v. Teva Pharm. USA, Inc.*, 752 F.3d 967, 977 (Fed. Cir. 2014) ("When assessing unexpected properties, therefore, we must evaluate the significance and 'kind' of expected results along with the unexpected results.") (citation omitted). Furthermore, any allegedly unexpected results must be "commensurate in scope" with the claims. *Genetics Inst., LLC v. Novartis Vaccines & Diagnostics, Inc.*, 655 F.3d 1291, 1308–09 (Fed. Cir. 2011). Although "absolute identity of scope" is not required, unexpected results have been found insufficient to support a conclusion of non-obviousness “where the evidence was plainly disproportionate to the scope of the claim.” *Id.* at 1308.

Example 1 of the ’921 patent involves the oxidation of HMF, of AMF, or of HMF/AMF mixtures using a Co/Mn/Br catalyst at 180°C for 1 hour with 20 bar air (i.e., ~ 4.2 bar pO2). Ex. 1001, 6:34–46. The resulting FDCA yields are reported in Table 1 of the patent. *Id.* at cols. 7–8 (Table 1). Patent Owner contends that “the reactions of Example 1 provide FDCA yields from HMF (Exp. Nos. 1a, 1e, 1i, and 1m) that are as high as 78%, which is about 30% higher than the FDCA yields from HMF reported in the ’732 publication and Partenheimer.” PO Resp. 36. Additionally, Table 2 of the ’921 patent provides a comparison of experiments 1d, 1h, 1l, and 1p (repeated from Table 1) with experiments 2a and 2b using the process disclosed in U.S. Patent Publication 2009/0156841,[9] which were conducted at 100°C and 30 bar for 2 hours. Ex. 1001, cols. 7–8 (Table 2). Based on these data, Patent Owner contends that “FDCA yields from AMF by the methods of the ’921 patent are up to 64.82 %, which is 20% higher than the FDCA yield from AMF reported in the ’841 publication.” PO Resp. 37. Finally, Patent Owner contends that “in Table 3, the ‘921 patent demonstrates yields as high as 42.6% for the ‘921 patent’s process operating at 180 ºC when oxidizing 5-MF,” whereas “RU ’177 reports a yield of 39% for a process starting with 5-MF.” *Id.* at 38.

In addition to the data presented in the ’921 patent itself, Patent Owner relies upon a series of experiments conducted in May 2016 by co-inventor Dr. Gert-Jan Gruter specifically for this proceeding, which

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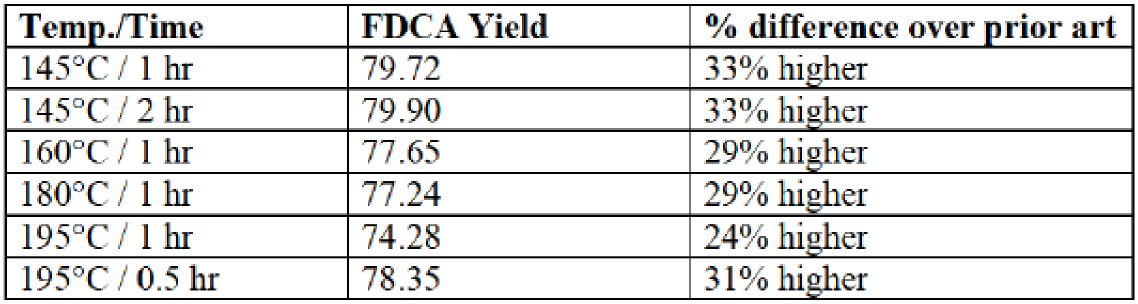
[9] Sanborn et al., US 2009/0156841 A1, published June 18, 2009 (Ex. 1022) (“the ’841 publication”).

“reproduce the experiments of Example 1 and Table 1 of the ‘921 patent at 180 °C, and carry out the same experiments at additional temperatures (145 °C, 160 °C, and 195 °C).” *Id.* at 38–40. Patent Owner contends that the “results of the experiments show unexpectedly high yields for the conversion of HMF to FDCA at temperatures between 140°C and 200°C” when “compared to the about 60% FDCA yield reported in the ’732 publication (and Partenheimer),” as shown in the table below:



Temp./Time	**FDCA Yield**	**% difference over prior art**
145°C / 1 hr	79.72	33% higher
145°C / 2 hr	79.90	33% higher
160°C / 1 hr	77.65	29% higher
180°C / 1 hr	77.24	29% higher
195°C / 1 hr	74.28	24% higher
195°C / 0.5 hr	78.35	31% higher

Id. at 40 (citing Ex. 2003 ¶¶ 139–142).

With respect to the foregoing evidence, Petitioners argue that product yields are not a claim limitation, and that the yields of the claimed processes overlap the yield percentages reported by the cited prior art references. Reply 17. Petitioners also argue that the experiments and data relied upon by Patent Owner are not “apple-to-apple” comparisons with the prior art because they involve “changes to variables known and expected to increase yields of FDCA.” *Id.* at 18. Petitioners further contend that “[t]he ’921 patent reports nothing more than what Partenheimer suggested and expected,” i.e., “increased yields with increased catalyst concentration.” *Id.* at 19. Additionally, Petitioners argue that Patent Owner’s arguments and evidence concerning unexpected results were not commensurate with the scope of the claims. Pet. 6, 17.

The evidence presented by Patent Owner tends to show that utilizing a reaction temperature within the claimed range of 140°C–200°C can lead to higher FDCA yields at least in some circumstances. In particular, the data in Table 1 of the ’921 patent shows FDCA yields ranging from 67.92% (experiment no. 1m) to 78.08% (experiment no. 1e) for the oxidation of HMF to FDCA at 180°C, and that Patent Owner’s more recent experiments show FDCA yields ranging from 74.28% to 79.90% for oxidation at other temperatures within the claimed range. Ex. 1001, cols. 7–8. We recognize that these yields are higher than the lower-temperature yields reported in Table 4 of the ’732 publication, which is the closest prior art.[10] Ex. 1002, 15–16. We also note that the reported percentages are higher than the “maximum obtainable [FDCA] yield [of] about 70%” discussed in Partenheimer, which tends to support a conclusion that the higher yields are “unexpected.” Ex. 1003, 105. We further recognize that FDCA yields obtained from the oxidation of AMF according to Example 1 of the ’921 patent (experiment nos. 1d, 1l, 1h, and 1p) are higher in comparison to the yields obtained according to the prior art process repeated in Example 2. Ex. 1001, 6:50–57, cols. 7–8 (Table 2).

At the same time, however, we cannot rule out the possibility that the higher FDCA yields relied upon by Patent Owner were due to differences in other operating parameters that could affect yield, such as reaction time and catalyst concentration, which were not shown to be held constant between the experiments conducted according to the prior art processes and the experiments conducted according to Example 1 of ’921 patent. *See* Ex.

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[10] Petitioners indicate “[t]here is no dispute that the ’732 publication is the closest prior art.” Pet. 7.

1009 ¶ 62 (Dr. Martin opining that "no conclusion can be drawn from [Patent Owner's] experiments in Table 2, used to demonstrate the effect of the oxidation temperature, because the oxidations were carried out using differen[t] pressures, different catalyst concentrations, and different substrate quantities"). Furthermore, given that only a 20 bar pressure that corresponded to approximately 4.2 bar pO_2 was used for Example 1, we find that the experiments relied upon to show unexpected results are not commensurate with the full scope of the claimed process, which allows for a pO_2 ranging from 1 to 10 bar . *See In re Peterson*, 315 F.3d 1325, 1331 (Fed. Cir. 2003) (affirming obviousness where the applicant claimed an alloy with 1–3% rhenium, yet presented unexpected results only for 2% rhenium, and evidence suggested that 3% rhenium possessed inferior properties); *In re Grasselli*, 713 F.2d 731, 743 (Fed. Cir. 1983) (concluding that unexpected results "limited to sodium only" were not commensurate in scope with claims to a catalyst having "an alkali metal"). Additionally, Patent Owner has not shown or explained why any increase in FDCA yield compared to the prior art would be considered a "difference in kind" rather than merely a "difference in degree." For example, as discussed in further detail below, Patent Owner has not demonstrated that the higher yields reported in the '921 patent led to a "commercially viable" process. *See Bristol-Myers Squibb Co.*, 752 F.3d at 977 ("While a 'marked superiority' in an unexpected property may be enough in some circumstances to render a compound patentable, a 'mere difference in degree' is insufficient.") (citations omitted).

Accordingly, we find that Patent Owner has not established unexpected results or criticality for the claimed temperature range.

b. Satisfaction of a Long-felt, But Unsolved Need

The satisfaction of a "long-felt, but unsolved need" by the claimed invention can serve as objective evidence of non-obviousness. *Ferring B.V. v. Watson Labs., Inc.-Florida,* 764 F.3d 1401, 1407 (Fed. Cir. 2014); *In re Cyclobenzaprine Hydrochloride Extended-Release Capsule Patent Litigation,* 676 F.3d 1063, 1081–83 (Fed. Cir. 2012). Patent Owner contends that that there was a long-felt need for a commercially viable process for making FDCA. PO Resp. 31–35.

Patent Owner relies upon a 2004 report from the U.S. Department of Energy identifying FDCA as one of 12 priority chemicals for establishing the "green" chemical industry of the future. *Id.* at 32 (citing Ex. 1001, 1:34–35; Ex. 2005). The 2004 Department of Energy report stated that "FDCA formation will require development of cost effective and industrially viable oxidation technology that can operate in concert with the necessary dehydration processes." Ex. 2005, 28; Ex. 2007 ¶¶ 11–12. Patent Owner further relies upon Dr. Gruter's declaration and other literature as suggesting that a commercially viable process for making FDCA has not been created before the '921 patent. PO Resp. 32–34 (citing Ex. 2007 ¶¶ 12–15; Ex. 1020; Ex. 2006).

The evidence supports Patent Owner's assertion that there was a long-felt, but unsolved need for a commercially viable process for making FDCA. However, we find that Patent Owner has not shown that the process claimed in the '921 patent solved that long-felt need. The experiments conducted and reported in the '921 patent were done in the laboratory rather than on a commercial scale. Ex. 2007 ¶¶ 23–26. It is undisputed that a commercial scale would be orders of magnitude higher. Ex. 1028 ¶¶ 29–32. Dr.

Schammel acknowledged that the skilled artisan would not have necessarily known how to scale the process of the ’921 patent up from the laboratory scale to a commercial scale. Ex. 2020, 77:22–78:22. As such, there is no evidence that the higher FDCA yields reported from the laboratory experiments described in the ’921 patent could have been obtained if the process was in fact scaled to a commercial level. Patent Owner has also not presented any evidence in this proceeding showing that its commercial process for making FDCA falls with the scope of the ’921 patent’s claims. *See* Tr. 34:8–36:14.

c. Copying

Finally, Patent Owner alleges that Petitioner copied its process by filing its own patent application that included an example describing a process for oxidizing HMF to FDCA that is embraced by the claims in the ’921 patent. PO Resp. 47. Specifically, Patent Owner points to example 48 of U.S. Patent Publication 2015-0183755 (“the ’755 publication) as showing a process in which HMF is oxidized at 190°C and at a pO_2 of 1.5–2.5 bars using a Co/Mn/Br catalyst. *Id.* (citing Ex. 2003 ¶¶ 163–168); Ex. 2004 ¶¶ 73–74. Petitioners assert that the examples of the ’755 publication are an extension of work previously done by the University of Kansas. Reply 24–25 (citing Ex. 2004). Regardless, we are not persuaded that a single example in a later-filed application that falls within the scope of the claims of the ’921 patent is evidence of copying in this case.

III. PATENT OWNER’S MOTION TO EXCLUDE

Patent Owner filed a Motion to exclude certain evidence. Paper 34. Petitioners filed an Opposition to Patent Owner’s Motion. Paper 38. Patent Owner filed a Reply in support of its Motion. Paper 40.

Patent Owner contends that ¶¶ 18–19, 26, 29, 31, 38–39, 41, 46–48, 50–52, 54–60, 62, 67, 69, 72, 75–76, 78–83, 85, 92–93, and 95 of Dr. Martin's Declaration (Ex. 1009) should be excluded under Fed. R. Evid. 402 (relevance) and Fed. R. Evid. 403 (confusing, waste of time) because they are not cited or referenced anywhere in the Petition. Paper 34, 2. Paper 40, 1–2. To the extent we have considered those portions of the Martin Declaration, we are not persuaded that they should be excluded as irrelevant, or as confusing or a waste of time. The mere fact that the paragraphs sought to be excluded were not cited specifically in the Petition does not mean they cannot provide relevant background information that may be considered.

Patent Owner also contends that ¶¶ 7, 8–19, 20–28, and 29–35 of Dr. Martin's Declaration # 2 (Ex. 1028) should be excluded as improper reply evidence. Paper 34, 4–8; Paper 40, 3–4. We are not persuaded that the paragraphs sought to be excluded are improper reply evidence, as we find that they properly respond to arguments raised in Patent Owner's Response. *See* 37 C.F.R. § 42.23(b) ("A reply may only respond to arguments raised in the corresponding opposition, patent owner preliminary response, or patent owner response."). Moreover, as recognized by the Federal Circuit, "the introduction of new evidence in the course of the trial is to be expected in *inter partes* review trial proceedings and, as long as the opposing party is given notice of the evidence and an opportunity to respond to it, the introduction of such evidence is perfectly permissible under the APA." *Genzyme Therapeutic Products Ltd. P'ship v. Biomarin Pharm. Inc.*, 825 F.3d 1360, 1366 (Fed. Cir. 2016). Here, Patent Owner did not seek to file a Sur-Reply to address any allegedly improper new Reply evidence.

Patent Owner also seeks to exclude Exhibits 1010, 1014, 1017, 1020, 1029, and 1030 under Fed. R. Evid. 402 (relevance), 403 (confusing, waste of time), and/or 802 (hearsay). To the extent we have considered these exhibits, we are not persuaded that they should be excluded as irrelevant or as confusing or a waste of time. Furthermore, the documents are not relied upon for the "truth of the matter asserted," but rather for the fact that they disclosed certain information regardless of whether it was true or not. *See REG Synthetic Fuels, LLC v. Neste Oil Oyj*, 841 F.3d 954, 964 (Fed. Cir. 2016) (noting that a statement is not hearsay if "the communication (as opposed to the truth) ha[d] legal significance"). Furthermore, the documents otherwise appear to fall into an exception to the hearsay rule, such as the public records exception. *See* Fed. R. Evid. 803.

Accordingly, we deny Patent Owner's Motion to exclude evidence.

IV. PATENT OWNER'S MOTION FOR OBSERVATIONS

Patent Owner filed a Motion for Observation on the cross-examination testimony of Dr. Martin. Paper 35. Petitioners, in turn, filed a Response. Paper 39. We have considered Patent Owner's observations and Petitioners' responses in rendering this Final Written Decision, and accorded the cross-examination testimony appropriate weight where necessary.

V. CONCLUSION

For the foregoing reasons, we conclude that Petitioners have not shown by a preponderance of the evidence that claims 1–5 and 7–9 of the '921 patent are unpatentable under 35 U.S.C. § 103(a).

VI. ORDER

Accordingly, it is:

ORDERED that claims 1–5 and 7–9 of U.S. Patent 8,865,921 B2 have not been shown to be unpatentable under 35 U.S.C. § 103(a);

FURTHER ORDERED that Patent Owner's Motion to Exclude is denied; and

FURTHER ORDERED that because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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