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Paper 29
Entered: March 13, 2015

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

BUTAMAX ADVANCED BIOFUELS LLC,
Petitioner,

v.

GEVO, INC.,
Patent Owner.

Case IPR2014-00250
Patent 8,546,627 B2

Before SHERIDAN K. SNEDDEN, CHRISTOPHER L. CRUMBLEY, and GEORGIANNA W. BRADEN, *Administrative Patent Judges*.

BRADEN, *Administrative Patent Judge*.

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

I. INTRODUCTION

A. Background

Butamax Advanced Biofuels LLC ("Petitioner") filed a Petition (Paper 1, "Pet.") to institute an *inter partes* review of claims 1–21 of U.S. Patent No. 8,546,627 B2 ("the '627 patent") pursuant to 35 U.S.C. §§ 311–319. Gevo, Inc. ("Patent Owner") did not file a Preliminary Response to the Petition. On May 22, 2014, we instituted an *inter partes* review of claims 1–21 on certain grounds of unpatentability alleged in the Petition. Paper 8 ("Dec. to Inst."). After institution of trial, the Patent Owner filed a Patent Owner Response (Paper 16, "PO Resp."), to which Petitioner filed a Reply (Paper 17, "Reply"). An oral argument was held on January 14, 2015.[1]

We have jurisdiction under 35 U.S.C. § 6(c). In this Final Written Decision, issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73, we determine Petitioner has shown by a preponderance of the evidence that all of the challenged claims of the '627 patent are unpatentable.

B. Related Proceedings

Petitioner informs us of no related litigations. Pet. 2. Concurrent with the present *inter partes* review, Petitioner also requested review of, and the Board instituted trial on, the following claims in patents in the same family as the '627 patent: claims 1–23 of U.S. Patent No. 8,193,402, Case IPR2014-00142 (PTAB May 22, 2014) (Paper 13); claims 1–21 of U.S. Patent No. 8,378,160, Case IPR2014-00143 (PTAB May 22, 2014) (Paper 9); and claims 1–19 of US Patent No. 8,487,149, Case IPR2014-00144 (PTAB May 22, 2014) (Paper 9). Because of overlapping issues between

[1] A transcript ("Tr.") of the oral hearing is included in the record. Paper 28.

the four proceedings, we consolidated the oral hearings for IPR2014-00250, IPR2014-00142, IPR2014-00143, and IPR2014-00144. *See* Paper 19. Additionally, Petitioner requested review of, and the Board instituted trial on claims 1–15 of unrelated U.S. Patent No. 8,373,012 in IPR2014-00402. *See* Paper 11.

C. The '627 Patent

The '627 patent, titled "Renewable Compositions," was issued on October 1, 2013, based on Application No. 13/441,468 ("the '468 application"), filed on April 6, 2012. The '468 application is a division of Application No. 12/327,723, filed on December 3, 2008 (issued as U.S. Patent No. 8,193,402). The '627 patent asserts its earliest priority claim to December 3, 2007, which is the filing date for Provisional Application Nos. 60/991,978 and 60/991,990.

The '627 patent relates to a method of fermenting a biomass with a microorganism, dehydrating the resultant alcohol to form biofuel precursors, and then subjecting the biofuel precursors to processes such as oligomerization, hydrogenation, and aromatization to form renewable jet fuel. Ex. 1001, 19:7–26. The Specification discloses several embodiments that include, for example, hydrolyzing a feedstock comprising a polysaccharide to produce fermentable hydrolysis products and fermenting the products in a medium with a microorganism to produce C_2–C_6 alcohol. *Id.* at 44:24–60. The method may include dehydrating the C_2–C_6 alcohol to produce C_2–C_6 olefins. *Id.* at 44:66–45:19. The olefins can be oligomerized to make C_6–C_{24} unsaturated oligomers. *Id.* at 47:55–66. Additionally, the C_6–C_{24} unsaturated oligomers can be hydrogenated to form C_6–C_{24} saturated alkanes (*id.* at 48:2–6), which can be combined with C_{10}–C_{14} aromatics to

form jet fuel that meets ASTM international specification D1655. *Id.* at 59:9–60:10.

Claims 1 and 18 are illustrative of the claimed subject matter in this trial and are reproduced below:

1. A process for preparing a renewable jet fuel comprising:

(a) treating biomass to form a feedstock;

(b) fermenting the feedstock with one or more species of microorganism, thereby forming one or more C_2–C_6 alcohols;

(c) dehydrating at least a portion of the one or more C_2–C_6 alcohols obtained in step (b), thereby forming a product comprising one or more C_2–C_6 olefins;

(d) isolating the one or more C_2–C_6 olefins;

(e) oligomerizing at least a portion of the one or more C_2–C_6 olefins isolated in step (d), thereby forming a product comprising one or more C_6–C_{24} unsaturated oligomers;

(f) optionally hydrogenating at least a portion of the product of step (e) in the presence of hydrogen, thereby forming a product comprising one or more C_6–C_{24} saturated alkanes; and

(g) combining the product of step (f) with one or more C_{10}–C_{14} aromatic hydrocarbons, thereby forming a jet fuel;

whereby the product of step (g) meets the requirements of ASTM D1655.

18. A renewable jet fuel or jet fuel precursor comprising a mixture of aromatic hydrocarbons and C_{11}–C_{14} aliphatic hydrocarbons.

D. Prior Art References Alleged to Support Unpatentability

The following prior art references were asserted in the instituted grounds:

Reference	Patent/Printed Publication	Date	Exhibit
D'Amore	US Patent Pub. No. 2008/0132741 A1	June 5, 2008	1002
ASTM D1655	American Society for Testing and Measurement, *Standard D1655-07: Standard Specification for Aviation Turbine Fuels*	July 1, 2007	1004
Cottrell	US Patent No. 4,861,930	Aug. 29, 1989	1006
Wilke	US Patent No. 4,359,533	Nov. 16, 1982	1007
Manzer	US Patent Pub. No. 2005/0228203 A1	Oct. 13, 2005	1008
Bradin	PCT Patent Pub. No. WO 2007/061903 A1	May 31, 2007	1010

E. Grounds of Unpatentability Instituted for Trial

The following table summarizes the challenges to patentability that were instituted for *inter partes* review:

Reference(s)	Grounds	Claim(s) challenged
D'Amore	§ 102(e)	1, 7, 11, and 14
D'Amore and ASTM D1655	§ 103(a)	1–7,11, 14, and 18–21
D'Amore, ASTM D1655, and Cottrell	§ 103(a)	8–10, 12, and 13
D'Amore, ASTM D1655, and Wilke	§ 103(a)	15
Bradin	§ 102(e)	18
Manzer and D'Amore	§ 103(a)	16 and 17

II. ANALYSIS

A. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are interpreted according to their broadest reasonable construction in light of the

specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *see In re Cuozzo Speed Techs., LLC,* 2015 WL 448667, at *6 (Fed. Cir. Feb. 4, 2015). Claim terms are given their ordinary and customary meaning as would be understood by one of ordinary skill in the art in the context of the entire disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007). Any special definition for a claim term must be set forth in the specification with reasonable clarity, deliberateness, and precision. *In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994).

1. Optional Language in Claims 1 and 16

Petitioner argues independent claims 1 and 16 should be construed as encompassing at least two processes because each recites optional steps (e.g., steps (f) and (g) of claim 1). Pet. 10–13. According to Petitioner, claim 1 encompasses the following two processes: Process 1 comprising steps (a)–(e) that culminates in the formation of one or more C_6–C_{24} unsaturated oligomers (i.e., one does not practice optional steps (f) and (g)); and Process 2 comprising steps (a)–(g) and the "whereby" clause that culminates in the formation of an on-specification jet fuel comprising one or more C_6–C_{24} saturated alkanes and one or more C_{10}–C_{14} aromatic hydrocarbons (i.e., one practices optional steps (f) and (g)). *Id*. at 10.

Patent Owner does not address the optional language in its Response.

The term "optionally," recited in step (f) of claim 1, is acceptable alternative language, which contains no ambiguity as to which alternatives are covered by the claim. *See, e.g.*, *Ex parte Wu*, 10 USPQ2d 2031 (BPAI 1989); *Ex parte Cordova*, 10 USPQ2d 1949 (BPAI 1987). The claim term "optionally" can be viewed in the same light as the use of "or," which has been construed to permit either or both of two alternatives, but not to require

that both exist. *See Brown v. 3M*, 265 F.3d 1349, 1352–53 (Fed. Cir. 2001); *Kustom Signals, Inc. v. Applied Concepts, Inc.*, 264 F.3d 1326, 1330–31 (Fed. Cir. 2001); *see also Titanium Metals Corp. v. Banner*, 778 F.2d 775, 782 (Fed. Cir. 1985) ("It is also an elementary principle of patent law that when, as by a recitation of ranges or otherwise, a claim covers several compositions, the claim is 'anticipated' if *one* of them is in the prior art.").

Therefore, the broadest reasonable interpretation of the claim language of claim 1 permits either alternative of the process described by steps (a)–(e) that culminates in the formation of one or more C_6–C_{24} unsaturated oligomers (i.e., one does not practice optional steps (f) and (g)), or the process described by steps (a)–(g) and the "whereby" clause that culminates in the formation of an on-specification jet fuel comprising one or more C_6–C_{24} saturated alkanes and one or more C_{10}–C_{14} aromatic hydrocarbons (i.e., one practices optional steps (f) and (g)).

Petitioner similarly contends that claim 16, which contains an optional step, encompasses two processes. Pet. 12. Step (v) of claim 16 is an optional step. The claim, as written, however, indicates that even if optional step (v) is not performed, step (vi) is required, because step (vi) states that the product from step (iv) or step (v) is to be aromatized. *See* Ex. 1001, 64:11–13. Additionally, step (vii) is optional and recites oligomerizing the product of step (vi) in the presence of the C_2–C_6 olefins from step (v). Thus, the language of optional step (vii) indicates that if step (v) is not performed, then step (vii) cannot be performed. Therefore, claim 16 recites three possible processes: (1) a process with only non-optional steps (i)–(iv) and (vi); (2) a process with all non-optional steps plus optional step (v); and (3) a process with all non-option steps plus both optional steps (v) and (vii).

Based on the foregoing, we find that the broadest reasonable interpretation of claim 16, in light of the Specification, encompasses those three alternative processes.

2. Technical Error in Claim 16

Petitioner contends that claim 16 contains a technical inaccuracy, because claim 16 recites "aromatizing one or more of the C_2–C_6 olefins obtained in step (iv)." Pet. 14. According to Petitioner, a person of ordinary skill in the relevant art would know that C_2–C_5 olefins would first have to be oligomerized to obtain C_6 or higher olefins that can be aromatized in step (vi), and claim 16 should be construed as such. *Id.* (citing Ex. 1011 ¶ 49). Patent Owner does not address the Petitioner's argument regarding an alleged technical inaccuracy in claim 16 in its Response.

Even if Petitioner's contention is correct and claim 16, as written currently, contains a technical error, we will not redraft a claim to make it operable or to sustain its validity. *See, e.g., Chef Am., Inc. v. Lamb-Weston, Inc.*, 358 F.3d 1371, 1374 (Fed. Cir. 2004); *Allen Eng'g Corp. v. Bartell Indus., Inc.*, 299 F.3d 1336, 1349 (Fed. Cir. 2002); *Elekta Instrument S.A. v. O.U.R. Scientific Int'l, Inc.*, 214 F.3d 1302, 1308–09 (Fed. Cir. 2000); *Process Control Corp. v. HydReclaim Corp.*, 190 F.3d 1350, 1357 (Fed. Cir. 1999); *Rhine v. Casio, Inc.*, 183 F.3d 1342, 1345 (Fed. Cir. 1999); *Quantum Corp. v. Rodime, PLC*, 65 F.3d 1577, 1584 (Fed. Cir. 1995); *Becton Dickinson & Co. v. C.R. Bard, Inc.*, 922 F.2d 792, 799 n.6 (Fed. Cir. 1990). We must construe a claim based on the way in which the claim is drafted. *Process Control*, 190 F.3d at 1357.

In any case, we do not find Petitioner's contention persuasive because the claims encompass C_6 olefins, which can be aromatized. Therefore, we decline to construe claim 16 so as to change the recited language.

3. Preamble in Claims 1 and 18

Petitioner contends that the preambles to claims 1 and 18, which recite "[a] renewable jet fuel or jet fuel precursor," are not limiting. Pet. 15; Reply 2–3. According to Petitioner, the claims' preambles impart no structure to the claim and, therefore, do not modify the source (e.g., renewable or non-renewable) of the aromatic hydrocarbons or C_{11}–C_{14} aliphatic hydrocarbons. *Id.* Patent Owner does not address the preamble in claim 18, but appears to argue that the preamble in the claim 1 should be construed as an express limitation. PO Resp. 4.

Preamble language that merely states the purpose or intended use of an invention generally is not treated as limiting the scope of a claim. *See Boehringer Ingelheim Vetmedica, Inc. v. Schering-Plough Corp.*, 320 F.3d 1339, 1345 (Fed. Cir. 2003); *Rowe v. Dror*, 112 F.3d 473, 478 (Fed. Cir. 1997). When the limitations in the body of the claim rely upon or derive essential structure from the preamble, however, then the preamble acts as a necessary component of the claimed invention and is limiting. *See Eaton Corp. v. Rockwell Int'l Corp.*, 323 F.3d 1332, 1339 (Fed. Cir. 2003).

In the present case, the preamble in claim 1 states an intended use for the recited processes. First, the body of each claim recites limitations that dictate that the processes use a "renewable" source for hydrocarbons, specifically claiming a step for "treating biomass to form a feedstock" and "fermenting the feedstock . . . thereby forming one or more C_2–C_6 alcohols" (Ex. 1001, 62:47–50). Therefore, there is no reliance upon the preamble to

define the subject matter of the claimed invention (i.e., the renewable source for the hydrocarbons), because it is expressed explicitly in the body of the claims. Second, for claim 1, the body of the claim recites that the process forms a jet fuel[2] (*id*. at 62:64–65) and that the jet fuel must meet the required specification for jet fuels (*id*. at 62:66–67). Therefore, the preamble language is redundant of the language recited specifically in the body of the claims and merely states an intended purpose of the recited claim. Accordingly, we find the preamble to claim 1 in the '627 patent not to be limiting.

The same reasoning and holding does not apply to claim 18. Unlike claim 1, the preamble of claim 18 does not state merely an intended use for the invention, but rather recites a specific characteristic of the source component of the invention. The '627 patent specifically defines "renewable" as encompassing compounds such as alcohols or hydrocarbons prepared from biomass using thermochemical methods (e.g., Fischer-Tropsch catalysts), biocatalysts (e.g., fermentation), or other processes. Ex. 1001, 9:8–15. Claim 18 is an example of a claim drafter choosing to use both the preamble and the body of the claim to define the subject matter of the claimed invention. *See, e.g., Bell Commc'ns Research, Inc. v. Vitalink Commc'ns Corp.*, 55 F.3d 615, 620 (Fed. Cir. 1995). Therefore, we find the preamble to claim 18 is limiting, and the source of the aromatic hydrocarbons or C_{11}–C_{14} aliphatic hydrocarbons recited must be "renewable" as the term is defined by the '627 patent, and the claimed

[2] Alternatively, if optional steps (f) and (g) are not performed, the process forms a jet fuel precursor.

product must be a "jet fuel" or "jet fuel precursor" as these terms are defined by the '627 patent.

B. Principles of Law

To prevail in its challenges to the patentability of the claims, a petitioner must establish facts supporting its challenges by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d). A claim is unpatentable under 35 U.S.C. § 102 if a prior art reference discloses every limitation of the claimed invention, either explicitly or inherently. *Glaxo Inc. v. Novopharm Ltd.*, 52 F.3d 1043, 1047 (Fed. Cir.1995); *see MEHL/Biophile Int'l Corp. v. Milgraum*, 192 F.3d 1362, 1365 (Fed. Cir. 1999) (holding that "[t]o anticipate, a single reference must teach every limitation of the claimed invention," and any limitation not taught explicitly must be taught inherently and would be so understood by a person experienced in the field); *In re Baxter Travenol Labs*., 952 F.2d 388, 390 (Fed. Cir. 1991) (the dispositive question is "whether one skilled in the art would reasonably understand or infer" that a reference teaches or discloses all of the elements of the claimed invention).

The principle of inherency, in the law of anticipation, requires that any information missing from the reference would nonetheless be known to be present in the subject matter of the reference, when viewed by persons experienced in the field of the invention. However, "anticipation by inherent disclosure is appropriate only when the reference discloses prior art that must *necessarily* include the unstated limitation, [or the reference] cannot inherently anticipate the claims." *Transclean Corp. v. Bridgewood Servs., Inc.*, 290 F.3d 1364, 1373 (Fed. Cir. 2002) (internal citation omitted); *see Hitzeman v. Rutter*, 243 F.3d 1345, 1355 (Fed. Cir. 2001) ("consistent with

the law of inherent anticipation, an inherent property must necessarily be present in the invention described by the count, and it must be so recognized by persons of ordinary skill in the art") (citations omitted); *In re Robertson*, 169 F.3d 743, 745 (Fed. Cir. 1999) (that a feature in the prior art reference "could" operate as claimed does not establish inherency). Thus, when a claim limitation is not set forth explicitly in a reference, evidence "must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill." *Continental Can Co.*, 948 F.2d 1264, 1268–69 (Fed. Cir. 1991) (citations omitted). It is not sufficient if a material element or limitation is "merely probably or possibly present" in the prior art. *Trintec Indus., Inc. v. Top–U.S.A. Corp.*, 295 F.3d 1292, 1295 (Fed. Cir. 2002) (citations omitted); s*ee W.L. Gore & Assocs., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1554 (Fed. Cir. 1983) (anticipation "cannot be predicated on mere conjecture respecting the characteristics of products that might result from the practice of processes disclosed in references") (citation omitted); *In re Oelrich*, 666 F.2d 578, 581 (CCPA 1981) (to anticipate, the asserted inherent function must be present in the prior art).

A claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art;

(3) the level of skill in the art; and (4) objective evidence of nonobviousness, i.e., secondary considerations. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

We analyze the instituted grounds of unpatentability in accordance with the above-stated principles.

C. Level of Ordinary Skill in the Art

In determining whether an invention would have been obvious at the time it was made, 35 U.S.C. § 103 requires us to determine the level of ordinary skill in the pertinent art at the time of the invention. *Graham v. John Deere*, 383 U.S. at 17. "The importance of resolving the level of ordinary skill in the art lies in the necessity of maintaining objectivity in the obviousness inquiry." *Ryko Mfg. Co. v. Nu-Star, Inc.*, 950 F.2d 714, 718 (Fed. Cir. 1991).

Petitioner contends that a person of ordinary skill in the art at the time of the '627 patent would have a Ph.D. in Chemistry, Chemical Engineering, or a similar related discipline and would have experience in organic chemistry and/or fuel chemistry, as well as transportation fuel production. Pet. 3–4; Ex. 1011 ¶ 16. Petitioner argues that, in the alternative, a person of ordinary skill in the art would have a Bachelor's degree in Chemistry, Chemical Engineering, or a similar related discipline and substantial experience in an industry involving organic chemistry and/or fuel chemistry, as well as transportation fuel production. Pet. 3–4; Ex. 1011 ¶ 16. Patent Owner states that one of ordinary skill in the art at the time of the '627 patent would have a Ph.D. in Chemistry, Chemical Engineering, or a similar related discipline and would have experience in fuel chemistry. Tr. 41:3–5. Based on our review of the '627 patent and the types of problems and

solutions described in the '627 patent and cited prior art, we conclude a person of ordinary skill in the art at the time of the '627 patent would have a Ph.D. degree in Chemistry, Chemical Engineering, or a similar related discipline and some experience in an industry involving organic chemistry and/or fuel chemistry. Based on the stated qualifications of Joseph T. Joseph, Ph.D. (Ex. 1011 ¶¶ 9–14) and his Curriculum Vitae (Ex. 1012), Petitioner's declarant meets the requirements of this definition. We further note that the applied prior art reflects the appropriate level of skill at the time of the claimed invention. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001).

D. Anticipation of Claims 1, 7, 11, and 14 by D'Amore

Petitioner contends D'Amore anticipates, under 35 U.S.C. § 102(e), claims 1, 7, 11, and 14 of the '627 patent. Pet. 19–24. For reasons that follow, we determine Petitioner has shown by a preponderance of the evidence that claims 1, 7, 11, and 14 are unpatentable under 35 U.S.C. § 102(e).

1. Overview of D'Amore

D'Amore discloses producing isobutanol (a C_2–C_6 alcohol) by culturing microorganisms in the presence of carbohydrates. Ex. 1002 ¶¶ 23, 56. D'Amore specifically teaches converting isobutanol into butene (a C_2–C_6 olefin) in the presence of a catalyst (*id.* ¶ 56, Fig. 1) and converting dimerized butene into isooctane (*id.* ¶¶ 64, 76). D'Amore also teaches alkylating C_6–C_9 aromatics with butene to produce C_{10}–C_{13} aromatic compounds. *Id.* ¶¶ 67–71. D'Amore states that butane produced by the disclosed processes is useful as an intermediate for the production of transportation fuels, including jet fuel. *Id.* ¶ 20.

2. Analysis

a. D'Amore Qualifies as 102(e) Prior Art

D'Amore was filed on June 13, 2007, published on June 5, 2008, and claims priority to U.S. Provisional Application No. 60/814,137 ("the '137 application"), filed on June 16, 2006. *See* Ex. 1003. The disclosure in the '137 application (Ex. 1003) is the same disclosure found in D'Amore (Ex. 1002). Ex. 1011 ¶ 59. Thus, D'Amore qualifies as prior art to the claims of the '627 patent under 35 U.S.C. § 102(e) as of the '137 application's filing date.

b. Independent Claim 1

Petitioner contends D'Amore, as summarized in the overview above, discloses each limitation of claim 1 of the '627 patent, except for step (g). Pet. 19–22. Petitioner also contends that steps (f) and (g) of claim 1 are optional steps and are not required elements for the claimed process. *Id*. at 19–20 n.1. According to Petitioner, D'Amore discloses a process to produce renewable hydrocarbons useful in transportation fuels, such as jet fuels. *Id*. at 21 (citing Ex. 1002 ¶¶ 4, 20; Ex. 1003, 1:16–24, 3:12–16). Petitioner relies on the Declaration of Dr. Joseph (Ex. 1011) to support its contentions of anticipation. Dr. Joseph testifies that D'Amore discloses a process for making renewable hydrocarbons. Ex. 1011 ¶ 62.

Patent Owner disagrees with Petitioner's characterization of D'Amore and argues that D'Amore does not disclose, directly or inherently, a process for producing "a renewable jet fuel" as recited in the preamble of claim 1. PO Resp. 3, 6. According to Patent Owner, the isooctanes described in D'Amore are not suitable as a jet fuel. *Id*. at 4, 6. Patent Owner concludes that process of D'Amore "in fact, produces a fuel which ***cannot*** find

practical application as a jet fuel," even if not held strictly to the ASTM standard. *Id*. at 6.

As discussed above, the preamble for claim 1 is not limiting. *See supra*, Section II.A.3. Therefore, we are not persuaded by Patent Owner's contention that to anticipate the process of claim 1, a reference must disclose, directly or inherently, a process for producing "a renewable jet fuel."

Additionally, as discussed above, the claim term "optionally" permits either or both of two alternative processes encompassed by claim 1, but does not require that both exist. *See supra*, Section II.A.1 (citing *Brown*, 265 F.3d at 1352–53; *Kustom Signals*, 264 F.3d at 1330–31). Claim 1 recites that at step (f) the claim process can include "optionally hydrogenating at least a portion of the product of step (e)," while step (g) recites "combining the product of step (f) with one or more C_{10}–C_{14} aromatic hydrocarbons, thereby forming jet fuel." Thus, to anticipate claim 1 of the '627 patent, a reference need only disclose each of steps (a)–(e); a reference need not disclose the optional steps (f) and (g). Because step (g) requires a product produced from step (f), if step (f) is not performed, then step (g) cannot be performed and a product of step (g) will not be formed.

We are persuaded that D'Amore discloses each required step (a)–(e) of claim 1. First, D'Amore discloses steps (a) and (b) by treating an aqueous stream of biomass-derived carbohydrates that are fermented with microorganisms to create a fermentation broth that produces isobutanol ($C_4H_{10}O$, an alcohol). Ex. 1002 ¶ 56. Second, D'Amore discloses step (c) by dehydrating of the aqueous stream to isolate the isobutanol, which is converted by an acid catalyst into butene (C_4H_8, an alkene olefin). *Id*.

¶¶ 56–57. Third, D'Amore discloses step (d) by distilling the butene from any unconverted isobutanol. *Id*. ¶ 57. Lastly, D'Amore discloses step (e) by oligomerizing butene into isooctene (C_8H_{16}, an unsaturated oligomer). *Id*. ¶ 64. D'Amore also discloses step (f) by converting the isooctene to isooctane (C_8H_{18}, a saturated alkane) using a hydrogenation catalyst in the presence of hydrogen. *Id*. ¶ 76. D'Amore states that the isooctane can be used as a fuel additive. *Id*. ¶ 64. Therefore, we find that D'Amore discloses the required steps (a)–(e), as well as step (f), of claim 1.

Accordingly, we find that Petitioner has shown by a preponderance of the evidence that claim 1 is anticipated under 35 U.S.C. § 102(e) by D'Amore.

c. Dependent Claims 7, 11, and 14

Claims 7, 11, and 14 depend from claim 1, and Petitioner contends that D'Amore discloses embodiments that teach aspects of each dependent claim. Pet. 37–41. Patent Owner does not provide contentions regarding additional limitations recited in the dependent claims. PO Resp. 7. After careful consideration of the language recited in claims 7, 11, and 14, we are satisfied D'Amore discloses the steps recited in the claims. *See* Ex. 1002, ¶¶ 21, 50, 75 (disclosing dehydrating and oligomerizing in the presence of an acidic catalyst, as recited in claim 7), ¶¶ 56–57, 64 (disclosing a process for preparing a renewable jet fuel, as recited in claim 11), ¶¶ 5–8 (disclosing removing C_2–C_6 alcohols from feedstock prior to dehydration, as recited in claim 14).

Accordingly, we find that Petitioner has shown by a preponderance of the evidence that claims 7, 11, and 14 are anticipated under 35 U.S.C. § 102(e) by D'Amore.

E. Obviousness of Claims 1–7, 11, 14, and 18–21 over D'Amore in view of ASTM D1655

Petitioner argues that the combination of D'Amore and ASTM D1655 renders each of claims 1–7, 11, 14, and 18–21 obvious. Pet. 24–38. In view of the overview of D'Amore provided above (*see supra*, Section II.D.1) and for reasons that follow, we determine Petitioner has shown by a preponderance of the evidence that claims 1–7, 11, 14, and 18–21 are unpatentable under 35 U.S.C. § 103(a).

1. Overview of ASTM D1655

ASTM D1655 describes standard specifications for aviation turbine fuel (i.e., jet fuel). Ex. 1004. Such specifications include the materials and manufacture of jet fuel, how the jet fuel is tested, and the required performance characteristics of such fuel. *Id.*

2. Analysis

a. Independent Claim 1

D'Amore describes an invention useful for the production of intermediate compounds used in transportation fuels such as jet fuel. Ex. 1002 ¶ 20. Specifically, D'Amore teaches reacting aromatic compounds with butene in order to produce a C_{10}–C_{13} substituted aromatic compound. Ex. 1002 ¶ 67. D'Amore further discloses recovering C_{10}–C_{13} substituted aromatic compounds via distillation and adding such compounds to transportation fuel. *Id.* ¶ 71.

D'Amore does not disclose explicitly combining aromatic compounds with C_6–C_{24} saturated alkanes (i.e, the product of step (f)) in order to produce a transportation fuel as required in step (g) of claim 1. As discussed in the preceding sections, steps (f) and (g) of claim 1 are optional, and need not be disclosed by D'Amore. Even if the steps were not optional, however,

Petitioner contends that a person of ordinary skill in the art would have had reason to reach the invention recited in claim 1 based on the combined teachings of D'Amore and ASTM D1655, which discloses the standards for jet fuel (Ex. 1004). Pet. 24–25.

First, according to Petitioner, a person of ordinary skill in the art would have had reason to review and meet the ASTM specifications when preparing a jet fuel, because Federal Aviation Administration ("FAA") regulations require compliance with ASTM standards in order to receive approval for the use and sale of jet fuel. Pet. 25; Ex. 1011 ¶¶ 17, 69. Second, Petitioner contends that one of ordinary skill in the art would have looked to D'Amore for processes for producing isooctane and C_{10}–C_{13} alkylated aromatics, which are intermediate compounds used in the production of jet fuel. Pet. 24–26. Lastly, Petitioner reasons that a person of ordinary skill in the art would have had motivation to modify the products of D'Amore to meet the ASTM D1655 specification in order to have a commercially useful fuel. Pet. 25; Ex. 1011 ¶¶ 75–80.

Petitioner contends that one of ordinary skill would have combined the teachings of D'Amore with the specification of ASTM D1655 to arrive at the process recited in independent claim 1 with a reasonable expectation of success. Petitioner's position is supported by the testimony of Dr. Joseph, who states "D'Amore further teaches producing other reaction products, e.g., C_{10}–C_{13} alkylated aromatics, from the butenes. The isooctane and C_{10}–C_{13} alkylated aromatics so produced are used in the production of transportation fuels, including jet fuel, as well as fuel additives." Ex. 1011 ¶ 72. Dr. Joseph further opines that, although D'Amore does not explicitly state that its isooctanes or alkylated aromatics meet any ASTM standards, a person of

skill in the art would have had every reason to modify D'Amore's processes to meet those standards, because the EPA and FAA use ASTM standards as part of their approval process to determine whether fuels can be sold in the United States. *Id*. ¶ 73.

Patent Owner contests Petitioner's position, arguing that ASTM D1655 merely provides a set of metrics to determine whether or not a given composition meets the limitations of the subject ASTM standard. PO Resp. 7–10. Patent Owner contends ASTM D1655 does not provide any disclosure or guidance regarding a ***process*** to make a renewable jet fuel that meets the requirements of ASTM D1655. *Id*. at 7–8. According to Patent Owner, a person of skill in the art would need a reference detailing the process steps between D'Amore and ASTM D1655 in order to create a product that would comply with the specification in ASTM D1655, because such information is not evidently and indisputably within the common knowledge of those skilled in the art. *Id*. at 8; Tr. 42:14–43:8.

Patent Owner contends that the Declaration of Dr. Joseph cannot support a finding of obviousness based on D'Amore and ASTM D1655, because: (1) the testimony is conclusory (PO Resp. 8); (2) claim rejections must be based on prior art (*id*. at 9); and (3) rather than merely relying on the opinion of Dr. Joseph, a reference should be provided to establish that modifying the process of *D'Amore* as proposed was obvious (*id*. at 9).

Despite Patent Owner's contentions, we are persuaded by Petitioner's arguments and find that a person of ordinary skill in the art could have combined the teachings of D'Amore and ASTM D1655 to reach the invention recited in claim 1, and would have been motivated to do so. As discussed above, the level of skill in the art is that of a person with a doctoral

degree in chemistry or related discipline (*see supra*, Section II.C.), and it is easier to establish obviousness under a higher level of ordinary skill in the art. *Kinetic Concepts, Inc. v. Smith & Nephew, Inc.*, 688 F.3d 1342, 1366 (Fed. Cir. 2012); *see also Innovention Toys, LLC v. MGA Entm't, Inc.*, 637 F.3d 1314, 1323–24 (Fed. Cir. 2011) (finding that a less sophisticated level of skill generally favors a determination of nonobviousness, while a higher level of skill favors the reverse). Given this high level of skill in the art, we credit the testimony of Dr. Joseph that a person of ordinary skill in the art would have had reason to modify the isooctanes of D'Amore to meet the ASTM D1655 specification (Ex. 1011 ¶¶ 73–76), and that such modifications could have been accomplished using routine optimization techniques that were common in the art (*id*. ¶ 76). Dr. Joseph cites to multiple publications providing several examples of well-known techniques to produce a mixture of saturated alkanes and aromatic hydrocarbons that meet ASTM D1655. *Id*. ¶¶ 26, 27, 29, 31, 76–78 (citing Exs. 1002, 1003, 1006, 1008, 1009, 1013, 1014, 1015, 1019). Thus, we are persuaded that a Ph.D. chemist would have knowledge of routine techniques as discussed by Dr. Joseph and would have had a reasonable expectation that such techniques would be successful. *See, e.g.*, *Randall Mfg. v. Rea*, 733 F.3d 1355, 1363 (Fed. Cir. 2013) (recognizing that combining familiar elements with known functions, according to known methods, and yielding predictable results likely is obvious).

We are unpersuaded by Patent Owner's contention that "Petitioner attempts to circumvent the requirement that claims rejections be based on prior art by relying on Dr. Joseph's opinions." PO Resp. 9. Rather, we conclude that Petitioner relies on the testimony of Dr. Joseph to indicate the

knowledge of one of ordinary skill in the art in order to demonstrate that the teachings of D'Amore, in view of the teachings ASTM D1655, as understood by one of ordinary skill in the art, would have rendered the challenged claims obvious at the time of the invention. *See* Ex. 1011 ¶¶ 26, 27, 29, 31, 76–78 (citing Exs. 1002, 1003, 1006, 1008, 1009, 1013, 1014, 1015, 1019).

We also are unpersuaded by Patent Owner's contentions that:

> [I]f the presently claimed process were indeed obvious, and the knowledge in the art was so readily known and available to one skilled in the art, petitioner would not rely on the opinions of Dr. Joseph, but rather, would simply provide a reference to establish that modifying the process of D'Amore as proposed was obvious

(PO Resp. 9), because the Supreme Court has cautioned against the overemphasis on publications and the explicit contents of issued patents during an obviousness analysis. *KSR*, 550 U.S. at 415–16. In *KSR*, the Supreme Court criticized a rigid approach to determining obviousness based on the disclosures of individual prior art references, with little recourse to the knowledge, creativity, and common sense that an ordinarily skilled artisan would have brought to bear when considering combinations or modifications. *Id.* at 415–22. Thus, we conclude that a person with a doctoral degree in chemistry would not need a reference detailing the process steps between D'Amore and ASTM D1655 in order to create a product that would comply with the specification in ASTM D1655.

Additionally, we find Patent Owner's reliance on the Board's Decision in IPR2014-00402 regarding an unrelated patent, which "held that even a reference teaching trimers and tetramers, in combination with

D'Amore, does not, in fact, teach or suggest a process for preparing fuels comprising C16 oligomers," to be misplaced. PO Resp. 9–10. In IPR2014-00402, the Board denied institution of an obviousness challenge that was based on the combination of D'Amore and Jhung.[3] According to the Board, Jhung indicated that trimers and tetramers were impurities, the production of which should be avoided. *See* IPR2014-00402, slip op. at 14 (PTAB Aug. 8, 2014) (Paper 11). Thus, the Board concluded that a person of ordinary skill in the art would have no motivation to combine the teachings in Jhung (to avoid trimers and tetramers) with the teachings in D'Amore for producing reaction products, e.g., C_{10}–C_{13} alkylated aromatics, from the butenes. *Id*. at 14–15. The Board's conclusion in IPR2014-00402, premised on a different combination of references, does not mandate a similar outcome for the challenged claims in the present case.

Accordingly, we find Dr. Joseph's testimony persuasive and hold that Petitioner has shown by a preponderance of the evidence that claim 1 is unpatentable under 35 U.S.C. § 103(a) for obviousness in view of the disclosures of D'Amore and ASTM D1655.

b. Independent Claim 18

Claim 18 recites a renewable jet fuel or jet fuel precursor comprising a mixture of aromatic hydrocarbons and C_{11}–C_{14} aliphatic hydrocarbons. Ex. 1001, 63:29–31. Claim 18's preamble is limiting, so claim 18 requires that the source of the aromatic hydrocarbons or C_{11}–C_{14} aliphatic hydrocarbons recited must be "renewable" as the term is defined by the '627 patent. *See supra*, Section II.A.3. The '627 patent defines "renewable,"

[3] Jhung et al., Int'l Pub. No. WO 2007/091862 A1 ("Jhung").

with regard to compounds such as alcohol or hydrocarbons, as compounds prepared from biomass using thermochemical methods (e.g. Fischer-Tropsch catalysts), biocatalysts (e.g., fermentation), or other processes. Ex. 1001, 9:8–14.

Petitioner contends that claim 18 would have been obvious over D'Amore in view of ASTM D1655, because D'Amore teaches processes for making renewable isooctanes and alkylated aromatics that can be used as biofuel components in transportation fuels, including jet fuels. Pet. 33–34 (citing Ex. 1011 ¶ 75; Ex. 1002 ¶ 20).

Petitioner's position is supported by the testimony of Dr. Joseph, who explains that a person of ordinary skill in the art would have arrived at a method of preparing a product comprising C_{12} saturated alkanes (i.e., aliphatic hydrocarbons) and aromatic compounds, based on the combination of D'Amore and ASTM DI655, with a reasonable expectation of success. Ex. 1011 ¶ 105. According to Dr. Joseph, a skilled practitioner using the methods taught in D'Amore, armed with only common sense and knowledge of techniques in the art would have arrived at the product of claim 18 with a reasonable expectation of success because it would have required no more than routine optimization to obtain a desirable product with the claimed composition. *Id.*

Patent Owner does not address the application of D'Amore and ASTM D1655 to claim 18, and instead, treats claim 18 as a dependent claim. PO Resp. 10.

Based on the evidence of record, we find that D'Amore teaches processes for making renewable isooctanes and alkylated aromatics using microbial fermentation methods. Ex. 1002 ¶ 34. D'Amore specifically

states that "[o]ne advantage to the microbial (fermentative) production of isobutanol is the ability to utilize feedstocks derived from renewable sources, such as corn stalks, corn cobs, sugar cane, sugar beets or wheat, for the fermentation process." *Id.* ¶ 22. Microbial fermentation of a biomass is one of the processes specifically identified in the '627 patent as creating a renewable hydrocarbons. *See* Ex. 1001, 9:8–14. We also find that D'Amore teaches that the compounds produced by its methods can be used as components in transportation fuels, including jet fuels. Ex. 1002 ¶ 20.

We further find that a person of ordinary skill in the art could have combined the teachings of D'Amore and ASTM D1655 to reach the invention recited in claim 18, and would have been motivated to do so. Specifically, we credit the testimony of Dr. Joseph that a person of ordinary skill in the art would have had reason to modify the isooctanes of D'Amore to meet the ASTM D1655 specification (Ex. 1011 ¶¶ 73–76, 105), and that such modifications could have been accomplished using routine optimization techniques that were common in the art (*id*. ¶ 76).

Accordingly, we find Dr. Joseph's testimony persuasive and hold that Petitioner has shown by a preponderance of the evidence that claim 18 is unpatentable under 35 U.S.C. § 103(a) for obviousness in view of the disclosures of D'Amore and ASTM D1655.

c. Dependent Claims 2–7, 11, 14, and 19–21

Petitioner also argues that claims 2–7, 11, 14, and 19–21 are unpatentable under 35 U.S.C. § 103(a) for obviousness over D'Amore and ASTM D1655. Pet. 24–38. For example, claim 2 recites that the dehydrating, oligomerizing, and hydrogenating steps of the process of claim 1 "are each carried out in the presence of a dehydration catalyst, [an]

oligomerization catalyst, and a hydrogenation catalyst, respectively." The '627 patent teaches that the dehydration catalyst and oligomerizing catalyst can be acid catalysts. Ex. 1001, 63:18–21. D'Amore meets the claim limitations, because D'Amore discloses introducing the isobutanol-containing stream "into [a reaction vessel] containing an acid catalyst . . . capable of converting the isobutanol into at least one butene," i.e., a dehydration catalyst. Ex. 1002 ¶ 56. D'Amore also discloses contacting "[t]he at least one recovered butene . . . with at least one dimerization catalyst," i.e., an oligomerization catalyst. *Id.* ¶ 75. Finally, D'Amore discloses contacting "[t]he at least one recovered isooctene produced by the dimerization reaction . . . with at least one hydrogenation catalyst in the presence of hydrogen." *Id.* ¶ 76.

Another example is claim 11, which recites a "renewable jet fuel prepared by the process of claim 1." As discussed above, D'Amore describes an invention useful for the production of intermediate compounds used in transportation fuels such as jet fuel (Ex. 1002 ¶ 20), while ASTM D1655 discloses the standards for jet fuel (Ex. 1004). We are persuaded by Petitioner's position (Pet. 32–33) that a person of ordinary skill in the art would have had motivation to modify the isooctanes of D'Amore to meet the ASTM D1655 specifications.

Patent Owner does not address the application of D'Amore and ASTM D1655 to the dependent claims. PO Resp. 7.

We are persuaded by Petitioner's contentions regarding dependent claims 2–7, 11, 14, and 19–21. *See* Ex. 1002 ¶¶ 63, 74–76 (teaching dehydration, oligomerization, and hydrogenation can occur in different reaction zones, as recited in claims 3 and 4), ¶ 50 (teaching "at least one acid

[(dehydration)] catalyst can be a homogeneous or heterogeneous catalyst" as recited in claims 5 and 6), ¶¶ 21, 50, 75 (teaching dehydrating and oligomerizing in the presence of an acidic catalyst, as recited in claim 7), ¶¶ 5–8 (teaching removing C_2–C_6 alcohols from feedstock prior to dehydration, as recited in claim 14); Ex. 1004, 7, Table 1 (disclosing that a product to be used in a jet fuel should contain at most 25 vol. % aromatic compounds and suggesting that it would be desirable to limit the amount of aromatics because too much results in carbon and soot deposition, thus teaching claim 19); Ex. 1019, 189–195 (pentamethylheptane isomers and other branched chain C_{12} hydrocarbon isomers would be produced naturally during the oligomerization process as disclosed by D'Amore, thus teaching claim 20); *id.* (branched chain C_{12} hydrocarbon isomers would be produced naturally during the oligomerization process disclosed by D'Amore, thus teaching claim 21).

Accordingly, we find that Petitioner has shown by a preponderance of the evidence that claims 2–7, 11, 14, and 19–21 are unpatentable under 35 U.S.C. § 103(a) for obviousness in view of the disclosures of D'Amore and ASTM D1655.

F. Obviousness of Claims 8–10, 12, and 13 over D'Amore in view of ASTM D1655 and Cottrell

Petitioner argues that the combination of D'Amore, ASTM D1655, and Cottrell renders each of the challenged claims obvious. Pet. 38–44. In view of the overview of D'Amore and ASTM D1655 provided above (*see supra*, Sections II.D.1 and II.E.1) and for reasons that follow, we determine Petitioner has shown by a preponderance of the evidence that claims 8–10, 12, and 13 are unpatentable under 35 U.S.C. § 103(a).

1. Overview of Cottrell

Cottrell discloses a process for converting C_2–C_6 aliphatic hydrocarbons into aromatic hydrocarbons. Ex. 1006, Abstract. Moreover, Cottrell specifically teaches the conversion of C_2–C_6 aliphatic hydrocarbons (including olefins) into aromatic hydrocarbons via dehydrocyclodimerizations immediately followed by a hydrogenation reaction. *Id.* at 4:42–45, 52–60. Cottrell also discloses oligomerizing C_2–C_6 olefins, followed by aromatizing the olefin oligomers to form C_6 or higher aromatic compounds. *Id.* at 3:33–51, 5:38–42.

2. Analysis

Petitioner argues that Cottrell in combination with the disclosures of D'Amore and ASTM D1655 teaches all the limitations of claims 8–10, 12, and 13. Pet. 38–44. Petitioner contends that a person of ordinary skill in the art would have had a reason to combine Cottrell and D'Amore, because they are both directed to the reaction of olefins to make aromatic hydrocarbon products. Pet. 39; Ex. 1011 ¶ 117. Petitioner also contends a person of ordinary skill in the art would have had a reason to combine D'Amore and ASTM D1655, because D'Amore is directed to the production of transportation fuels, such as jet fuels, and ASTM D1655 provides industry specifications for jet fuels. Pet. 39. Furthermore, according to Petitioner, a person of ordinary skill in the art would have had a reason to combine ASTM D1655 and Cottrell, because ASTM D1655 teaches that aromatic hydrocarbons are components of jet fuels and Cottrell teaches how to obtain aromatic hydrocarbons. *Id.*

Patent Owner opposes Petitioner's position, arguing that Cottrell is silent with respect to any ASTM standard such as ASTM D1655, or a

process for preparing a renewable jet fuel meeting the specification of ASTM D1655. PO Resp. 11. According to Patent Owner, Cottrell cannot remedy any deficiencies found in D'Amore and ASTM D1655. *Id*. Therefore, Patent Owner concludes that ASTM D1655 and D'Amore in combination with Cottrell fail to disclose or suggest a process for preparing a renewable jet fuel meeting the requirements of ASTM D1655, as recited in independent claim 1. *Id*.

a. Claim 8

Claim 8 depends directly from independent claim 1. Ex. 1001, 63:22–27. Petitioner argues that a person of ordinary skill in the art would have arrived at the invention of claim 8 in the '627 patent by oligomerizing butane based on the process disclosed in D'Amore and then aromatizing the C_2–C_6 olefins dimers and trimers based on the processed disclosed in Cottrell. Pet. 40. According to Petitioner, the oligomerization and aromatizing process are routine in the art, and a person of ordinary skill in the art would have a reasonable expectation of success by using the disclosed processes. *Id*.; Ex. 1011 ¶ 123. We are persuaded by Petitioner's argument and conclude that the claims merely combine known processes (oligomerizing, aromatizing, and hydrogenation) for their known purpose to achieve a predictable result (preparing C_{10}–C_{14} aromatic hydrocarbons). *See KSR*, 550 U.S. at 416.

Furthermore, we are persuaded by Dr. Joseph's testimony that a person of ordinary skill would have had reason to combine the teachings of Cottrell, D'Amore, and ASTM D1655 in a manner that yields the process recited in claim 8. Ex. 1011 ¶ 117. Specifically, D'Amore and Cottrell are both directed to the reaction of olefins to make aromatic hydrocarbon

products, while ASTM D1655 teaches that aromatic hydrocarbons are components used in jet fuels. *Id*. ¶¶ 117–123.

Accordingly, we find Petitioner has shown by a preponderance of the evidence that claim 8 is unpatentable over Cottrell, D'Amore, and ASTM D1655.

b. Claim 9

Claim 9 depends from claim 8 and recites that one or more of the aromatized C_2–C_6 olefins are isolated from a dehydration step (claim 1, step (d)) and one or more of the C_2–C_6 olefin dimers are obtained from a oligomerization step (claim 1, step (e)). Ex. 1001, 63:27–29. Petitioner explains that D'Amore discloses dehydrating isobutanol to form butenes that can be isolated from a reaction mixture. Pet. 41–42; Ex. 1002 ¶ 21; Ex. 1011 ¶ 125. According to Petitioner, a person of ordinary skill in the art would have arrived at the claimed process of isolating C_2–C_6 olefins from a dehydration reaction and C_2–C_6 olefin dimers from an oligomerization reaction with a reasonable expectation of success. Pet. 42; Ex. 1011 ¶ 125. We are persuaded by Petitioner's argument and conclude that the claims merely combine known processes (dehydration, oligomerization, and aromatizing) for their known purpose to achieve a predictable result (obtaining C_2–C_6 dimers). *See KSR*, 550 U.S. at 416.

Furthermore, we are persuaded by Dr. Joseph's testimony that a person of ordinary skill would have arrived at the process recited in claim 9, because D'Amore teaches the production of butene (a C_4 olefin) from the dehydration of isobutanol and the dimerization of butene to form isooctene. Ex. 1011 ¶ 125.

Accordingly, we find Petitioner has shown by a preponderance of the evidence that claim 9 is unpatentable over Cottrell, D'Amore, and ASTM D1655.

c. Claim 10

Claim 10 depends from claim 8 and recites hydrogenating C_2–C_6 olefin oligomers (claim 1, step (f)) using hydrogen formed from the aromatization of C_2–C_6 olefin monomers, dimers, and trimers. Pet. 42; Ex. 1001, 63:30–32. Petitioner explains that Cottrell discloses that hydrogen created as a byproduct of the aromatization of C_2–C_6 olefins is used to hydrogenate a feed of hydrocarbons. Pet. 42; Ex. 1006, 3:33–35, 3:51–57, 4:40–50, 11:26–33; Ex. 1011 ¶ 127. Petitioner reasons that a person of ordinary skill in the art would have recognized that the hydrogen byproduct could be used to hydrogenate olefin oligomers and that such a use of the hydrogen byproduct of the aromatization reaction would have been a design choice based on a cost/benefit analysis of where use of the hydrogen byproduct would be the most advantageous. Pet. 42; Ex. 1011 ¶ 127. We are persuaded by Petitioner's argument and conclude that the claims merely combine known processes (oligomerizing, aromatizing, and hydrogenation) for their known purpose to achieve a predictable result (obtaining and using a hydrogen byproduct). *See KSR*, 550 U.S. at 416.

Furthermore, we are persuaded by Dr. Joseph's testimony that a person of ordinary skill would have had reason to combine the teachings of Cottrell, D'Amore, and ASTM D1655 in a manner that yields the inventions recited in claim 10. Ex. 1011 ¶ 117. Specifically, Cottrell discloses the aromatization of C_2–C_6 olefins to form aromatic compounds (Ex. 1006, 3:33–51), and the hydrogen produced as a byproduct of the reaction is used

to hydrogenate a feed of hydrocarbons (*id.* at 3:51–57, 4:40–50, 11:26–33). Ex. 1011 ¶ 127. Thus, we are persuaded by Dr. Joseph's testimony that a person of skill in the art would have a reasonable expectation of using hydrogen produced as a byproduct of an aromatization reaction to hydrogenate a feed of hydrocarbons because Cottrell teaches such a process. *See id.* ¶ 128.

Accordingly, we find Petitioner has shown by a preponderance of the evidence that claim 10 is unpatentable over Cottrell, D'Amore, and ASTM D1655.

d. Claims 12 and 13

Claim 12 depends from claim 8, while claim 13 depends from claim 10. Ex. 1001, 63:36–38. Petitioner contends D'Amore, in combination with ASTM D1655 and Cottrell, discloses a product produced by performing the steps of claim 8, resulting in a mixture of C_{10}–C_{14} aromatic compounds. Pet. 43. Petition specifically explains that D'Amore, in view of ASTM D1655 and Cottrell, teaches a renewable jet fuel produced by performing the process of D'Amore to obtain C_{12}–C_{16} saturated alkanes, which are aromatized by the process of Cottrell, and D'Amore teaches oligomerizing the resultant aromatics to produce alkylated benzenes, which can be added to jet fuel. *Id.* (citing Ex. 1011 ¶ 130). Petitioner concludes that a person of ordinary skill in the art reading D'Amore, ASTM D1655, and Cottrell, would have arrived at the claimed renewable jet fuel prepared by the process of claim 8 and would have had a reasonable expectation of success in doing so. *Id.* (citing Ex. 1011 ¶ 131).

Petitioner contends D'Amore, in combination with ASTM D1655 and Cottrell, discloses a product produced by performing the steps of claim 10,

resulting in a mixture of C_{10}–C_{14} aromatic compounds and saturated alkanes. Pet. 44. Petitioner specifically explains that D'Amore, in combination with ASTM D1655 and Cottrell, teaches producing one or more of the saturated alkanes by hydrogenating one or more unsaturated oligomers using the hydrogen byproduct of an aromatization reaction. *Id.* Petitioner concludes that a person of ordinary skill in the art reading D'Amore, ASTM D1655, and Cottrell, would have arrived at the claimed renewable jet fuel prepared by the process of claim 10 and would have had a reasonable expectation of success in doing so. *Id.* (citing Ex. 1011 ¶ 134).

We have considered fully Petitioner's arguments and evidence concerning the obviousness of dependent claims 12 and 13 in view of the combination of Cottrell, D'Amore, and ASTM D1655 (Pet. 43–44) and are persuaded Petitioner has shown by a preponderance of the evidence that claims 12 and 13 are unpatentable over the cited references for the reasons set forth above.

G. Obviousness of Claim 15 over D'Amore in view of ASTM D1655 and Wilke

Petitioner contends that claim 15 would have been obvious over D'Amore, ASTM D1655, and Wilke. Pet. 44–45. In view of the overview of D'Amore and ASTM D1655 provided above (*see supra*, Sections II.D.1 and II.E.1) and for reasons that follow, we determine Petitioner has shown by a preponderance of the evidence that claim 15 is unpatentable under 35 U.S.C. § 103(a).

1. Overview of Wilke

Wilke teaches a process for producing and recovering alcohols using a combination of vacuum fermentation and vacuum distillation. Ex. 1007, Abstract. Wilke further discloses the fermentative production of alcohols

below atmospheric pressure, such that a vapor of aqueous alcohol is removed. *Id.* at 5:12–17, 7:67–8:1. Wilke specifically discloses that "[t]he pressure of the fermentation can be subatmospheric on the order of about 50 to 500 mm Hg." *Id.* at 5:12–17. Wilke also teaches that removing alcohol during the fermentative process by fermenting at reduced pressure would benefit microorganism catalysts by relieving any alcohol toxicity. *Id.* at 3:25–28.

2. Analysis

Claim 15 depends from claim 14, and further recites that the C_2–C_6 alcohol is removed from feedstock by a process comprising fermenting the culture at subatmospheric pressure such that an aqueous vapor of C_2–C_6 alcohol is removed. Ex. 1001, 63:40–43. Petitioner argues that Wilke teaches this limitation of claim 15. Pet. 45. According to Petitioner, determining fermentation pressure is a design choice based on a cost/benefit analysis, and fermenting at below atmospheric pressure would have been a matter of common sense and routine optimization based on the knowledge of techniques that would have yielded nothing more than predictable results. *Id.*; Ex. 1001 ¶ 137. Petitioner reasons that a person of ordinary skill in the art would have had a reason to, and the knowledge to, arrive at the process of claim 15 with a reasonable expectation of success. Pet. 45.

Patent Owner opposes Petitioner's position, arguing that Wilke is also silent with respect to any ASTM standard such as ASTM D1655, or a process for preparing a renewable jet fuel meeting the specification of ASTM D1655. PO Resp. 12–13. According to Patent Owner, Wilke cannot remedy any deficiencies found in D'Amore and ASTM D1655. *Id*. Patent Owner contends that ASTM D1655 and D'Amore in combination with

Wilke fail to disclose or suggest a process for preparing a renewable jet fuel that meets the requirements of ASTM D1655, as required by claim 1. *Id*.

We are persuaded by Petitioner's analysis, as supported by Dr. Joseph's testimony, that one of ordinary skill would have arrived at the process recited in dependent claim 15 with a reasonable expectation of success given the disclosures of Wilke, D'Amore, and ASTM D1655.

Accordingly, we determine that Petitioner has shown by a preponderance of the evidence that claim 15 is unpatentable over Wilke, D'Amore, and ASTM D1655.

H. Obviousness of Claims 16 and 17 over Manzer in view of D'Amore

Petitioner contends claims 16 and 17 would have been obvious over Manzer and D'Amore. Pet. 56–60. In view of the overview of D'Amore provided above (*see supra*, Section II.D.1) and for reasons that follow, we determine Petitioner has shown by a preponderance of the evidence that claims 16 and 17 are unpatentable under 35 U.S.C. § 103(a).

1. Overview of Manzer

Manzer is directed to the production of xylene (an aromatic hydrocarbon) from dimerized isobutylene. Ex. 1008, Abstract. Manzer specifically teaches dimerizing isobutylene (i.e., isobutene) and then aromatizing the isobutene dimers to form C_7 and C_8 aromatic hydrocarbons, such as toluene and xylene. *Id.* ¶¶ 12, 27, 30. Manzer also teaches multiple methods of producing isobutene, including a process of dehydrogenating isobutanol. *Id.* ¶ 12.

2. Analysis

Independent claim 16 is directed to a process of preparing aromatic hydrocarbons and includes steps for dehydrating C_2–C_6 alcohol to create C_2–

C_6 olefins, oligomerizing the olefins, and then aromatizing either the olefins or the oligomerized olefins to create C_6–C_{14} aromatic hydrocarbons. Ex. 1001, 63:44–64:19. Steps (v) and (vii) of claim 16 are optional steps.[4] Therefore, as discussed above, we find that claim 16 encompasses at least three processes: (a) process 1, with steps (i)–(vi); (b) process 2, with steps (i)–(vii); or (c) process 3, with steps (i)–(iv) plus step (vi).

As discussed previously, the claim term "optionally" permits any or all of multiple alternative elements, but does not require that all exist. *See* Section II.A.1 (citing *Kustom Signals*, 264 F.3d at 1330–31). Thus, to anticipate claim 16 of the '627 patent, a reference need only disclose each of these steps (i)–(iv) plus step (vi); a reference need not disclose the optional steps (v) and/or (vii).

Petitioner contends that D'Amore discloses steps (i)–(iv) because it teaches fermenting a feedstock and dehydrating the resulting renewable isobutanol to form renewable isobutene dimers. Pet. 57 (citing Ex. 1002 ¶¶ 21, 56, 64; Ex. 1011 ¶ 165). Petitioner also contends that Manzer, as summarized in the overview above, discloses steps (v) and (vi) of claim 16 of the '627 patent. *Id.* (citing Ex. 1008 ¶¶ 12, 27, 28, 31; Ex. 1011 ¶ 165). According to Petitioner, a person of ordinary skill in the art would have had a reason to combine Manzer and D'Amore, because they are both directed to reacting butenes to form aromatic compounds that are alkyl-substituted benzenes. Pet. 56 (citing Ex. 1011 ¶ 164). Petitioner reasons that a person of ordinary skill in the art would have had a reason to use the renewable

[4] Step (v) of claim 16 calls for oligomerizing olefins, while step (vii) calls for oligomerizing the C_6–C_{14} aromatic hydrocarbons produced from step (vi) with olefins to form C_8–C_{16} aromatic hydrocarbons.

isobutanol and isobutene of D'Amore in the process of Manzer, because renewable isobutanol and isobutene are appealing for multiple reasons. Pet. 57. Petitioner then concludes that claim 16 would have been obvious over the combined disclosures of Manzer and D'Amore. *Id.*

Patent Owner opposes Petitioner's position, arguing that Petitioner improperly relies on hindsight in asserting obviousness of the challenged claims based on Manzer. PO Resp. 13–14. Manzer discloses that "[t]he source of isobutylene can be any that is convenient, including but not limited to processes such as [1] the cracking of methyl tertiary butyl ether (MTBE), [2] the dehydration of isobutanol, [3] butane skeletal isomerization, and [4] the dehydrogenation of isobutane. Ex. 1008 ¶ 22. Patent Owner argues that Petitioner's selection of isobutanol dehydration from D'Amore as the source of isobutylene in Manzer's process is arbitrary and based on the hindsight knowledge of the claimed invention. PO Resp. 14. We disagree.

On this issue, the Federal Circuit's opinion in *In re Thomas* is informative. *See* 151 F. App'x 930 (Fed. Cir. 2005). In that case, one of the claims on appeal was directed to a computer implemented method for performing a survey, requiring email notification of registered participants as to research studies. *Id*. at 932. The Board affirmed an examiner's rejection of the claim for obviousness based on the combination of two prior art references. *Id*. at 934. On appeal to the Federal Circuit, the appellant argued that the Board erred in finding a motivation to combine because one of the references "suggests eight different methods of computer-based data collection, any one of which could be used to notify respondents, and that it does not suggest the particular desirability of email notification." *Id*. Rejecting this argument, the Federal Circuit pointed out: "for an

obviousness analysis, even the fact that 'a specific embodiment is taught to be preferred is not controlling, since all disclosures of the prior art, including unpreferred embodiments, must be considered.'" *Id*. (quoting *Merck & Co., Inc. v. Biocraft Labs., Inc*., 874 F.2d 804, 807 (Fed. Cir. 1989)).

Similarly in the present case, we must consider all disclosures of Manzer, which explicitly teaches dehydration of isobutanol as a source for isobutylene. Ex. 1008 ¶ 22. Manzer's teaching of other methods for creating isobutylene does not render the combination of this method with the teaching of D'Amore non-obvious.

We also disagree with Patent Owner's argument that claim 16 is not obvious as challenged because Manzer does not teach that isobutanol can be produced from a fermentation reaction that uses a biomass feedstock. PO Resp. 15. Petitioner specifically relies on D'Amore, which explicitly teaches distillation to recover isobutanol from fermentation broth, for this claim element. Pet. 57 (citing Ex. 1002 ¶¶ 21, 56, 64). The arguments presented by Patent Owner appear to attack the references individually, rather than in combination. PO Resp. 13–16. Nonobviousness cannot be established by attacking the references individually when the rejection is predicated upon a combination of prior art disclosures. *See In re Merck & Co., Inc.*, 800 F.2d 1091, 1097 (Fed. Cir. 1986). Further, in attacking the references individually, Patent Owner fails to address Petitioner's actual challenges to establish an insufficiency in the combined teachings of the references and show Petitioner has failed to carry its burden to demonstrate obviousness of claim 16.

In sum, we determine Petitioner has shown that the combination of Manzer and D'Amore teaches or suggests all the limitations of claim 16. In

addition, we are persuaded by the testimony of Dr. Joseph that one skilled in the art would have had a reason to combine these references and would have had a reasonable expectation that the modified method be successful in producing isobutanol. Ex. 1011 ¶¶ 164, 166, 168. We conclude similarly regarding dependent claim 17, because Manzer and D'Amore teach the further limitations of this claim. Pet. 59–60; Ex. 1011 ¶¶ 169, 170.

Accordingly, we determine that Petitioner has shown by a preponderance of the evidence that claims 16 and 17 are unpatentable over Manzer and D'Amore.

I. Anticipation of Claim 18 by Bradin

Petitioner contends claim 18 is anticipated by Bradin. Pet. 50–52.

1. Overview of Bradin

Bradin discloses jet fuels comprising components, such as alcohols and glycerol ethers, produced from renewable resources. Ex. 1010, Abstract; 1:12–13, 3:20–22, 8:1–2. Bradin specifically discloses that fuel can be derived from a renewable source such as farm crops (biodiesel) or from Fischer-Tropsch synthesis (syntroleum). *Id.* at 1:12–13. According to the Bradin Specification, "[s]ignificant efforts have been undertaken to provide renewable compositions that can replace all or part of jet fuel." *Id.* at 2:1–2. Bradin discloses that jet fuels are mixtures of compounds, including hydrocarbons, typically in the C_5–C_{15} range, as well as aromatics, typically in the C_5–C_{20} range. *Id.* at 1:29–2:2. Bradin further discloses that examples of hydrocarbons used in the production of jet fuels are cycloparaffins, n-paraffins, and isoparaffins, all of which are aliphatic hydrocarbons. *Id.*

2. Analysis

Claim 18 recites a "renewable" jet fuel or jet fuel precursor comprising a mixture of aromatic hydrocarbons and C_{11}–C_{14} aliphatic hydrocarbons. Pet. 51; Ex. 1001, 64:29–31. As discussed above, we find that the preamble of claim 18 is limiting, because it recites a specific characteristic of the source component of the invention as being "renewable."

Petitioner contends that Bradin discloses all the recited elements of claim 18. Pet. 51. According to Petitioner, Bradin discloses that jet fuels, comprising components such as alcohols and glycerol ethers, are produced from renewable resources such as farm crops (biodiesel) or from Fischer-Tropsch synthesis (syntroleum). *Id.* (citing Ex. 1010, 3:20–22, 8:1–2; Ex. 1011 ¶ 151). Petitioner explains that Bradin discloses jet fuels comprised of a mixture of aliphatic hydrocarbons (cycloparaffins, n-paraffins, and isoparaffins) and aromatic hydrocarbons. *Id.* (citing Ex. 1010, 1:29–2:2; Ex. 1011 ¶ 151). Such compounds are considered "renewable," according to the '627 patent Specification. Ex. 1001, 9:8–15.

Patent Owner contends Bradin does not anticipate claim 18, because Bradin discloses fuel additives, which may be renewable, rather than renewable jet fuels or jet fuel precursors as required by claim 18. PO Resp. 17. Patent Owner further argues that Bradin's statement that "[s]ignificant efforts have been undertaken to provide renewable compositions that can replace all or part of jet fuel" (Ex. 1010, 2:1–2) merely discloses that efforts are underway but fails to disclose the existence of renewable fuels or fuel precursors resulting from such efforts, beyond that of fuel additives. PO Resp. 17–18.

Contrary to Patent Owner's contentions, we are persuaded by Petitioner's position. Bradin specifically discloses:

> Hydrocarbons derived from Fischer-Tropsch synthesis have also been used as jet fuel, or incorporated into jet fuel. Such jet fuel or jet fuel blends are known in the art. The use of Fischer-Tropsch synthesis to form syntroleum is well known, as is the use of Fischer-Tropsch synthesis to form relatively low molecular weight olefins.

Ex. 1010, 12:15–18.

Bradin also discloses jet fuels comprised of a mixture of aliphatic hydrocarbons and aromatic hydrocarbons. Ex. 1010, 1:29–2:2. Given that the '627 patent defines "renewable" as including compounds such as alcohols or hydrocarbons prepared from biomass using thermochemical methods such as by Fischer-Tropsch catalysts (Ex. 1001, 9:8–15), we find that Bradin's disclosure of hydrocarbons derived from Fischer-Tropsch synthesis reads on the limitations recited in claim 18.

We, therefore, conclude, that Bradin discloses each recited element of the composition of claim 18 of the '627 patent. Accordingly, we determine that Petitioner has shown by a preponderance of the evidence that claim 18 is unpatentable over Bradin.

III. CONCLUSION

We conclude Petitioner has shown the following by a preponderance of the evidence:

1. Unpatentability of claims 1, 7, 11, and 14 under 35 U.S.C. § 102(e) for anticipation by D'Amore;

2. Unpatentability of claims 1–7, 11, 14, and 18–21 under 35 U.S.C. § 103(a) for obviousness over D'Amore and ASTM D1655;
3. Unpatentability of claims 8–10, 12, and 13 under 35 U.S.C. § 103(a) for obviousness over D'Amore, ASTM D1655, and Cottrell;
4. Unpatentability of claim 15 under 35 U.S.C. § 103(a) for obviousness over D'Amore, ASTM D1655, and Wilke;
5. Unpatentability of claims 16 and 17 under 35 U.S.C. § 103(a) for obviousness over Manzer and D'Amore; and
6. Unpatentability of claim 18 under 35 U.S.C. § 102(e) for anticipation by Bradin.

IV. ORDER

For the reasons given, it is

ORDERED that claims 1–21 of the '627 patent are unpatentable;

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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