

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

BUTAMAXTM ADVANCED BIOFUELS LLC,
Petitioner,

v.

GEVO, INC.,
Patent Owner.

Case IPR2013-00215
Patent 8,283,505 B2

Before RAMA G. ELLURU, CHRISTOPHER L. CRUMBLEY, and
ZHENYU YANG, *Administrative Patent Judges*.

YANG, *Administrative Patent Judge*.

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

I. INTRODUCTION

ButamaxTM Advanced Biofuels LLC (“Butamax”) petitioned for an *inter partes* review of claims 1–18 of U.S. Patent No. 8,283,505 B2 (“the ’505 patent”). Paper 2 (“Pet.”). On September 30, 2013, the Board instituted trial to review all challenged claims on several obviousness grounds. Paper 10 (“Dec.”). Thereafter, Patent Owner, Gevo, Inc. (“Gevo”), filed a Response (Paper 22 (“PO Resp.”)) and Butamax filed a Reply (Paper 33 (“Reply”)). Oral hearing was held on April 30, 2014. *See* Paper 46 (“Tr.”).

The Board has jurisdiction under 35 U.S.C. § 6(c) and issues this final written decision pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73. For the reasons provided below, we conclude that Butamax has proved by a preponderance of the evidence that claims 1–18 of the ’505 patent are unpatentable.

A. *Related Proceedings*

Concurrent with the present *inter partes* review, Butamax also petitioned for review of, and the Board instituted trial on, claims 1–28 of U.S. Patent No. 8,304,588, a patent in the same family as the ’505 patent. *See ButamaxTM Advanced Biofuels LLC v. Gevo, Inc.*, Case IPR2013-00214 (PTAB Sept. 30, 2013) (Paper 11). Because of overlapping issues between the two proceedings, we consolidated the oral hearings for IPR2013-00214 and IPR2013-00215. *See* Tr. of Oral Hr’g at 2:17–18, *ButamaxTM Advanced Biofuels LLC v. Gevo, Inc.*, Case IPR2013-00214 (PTAB Apr. 30, 2014) (Paper 45) (“IPR2013-00214 Tr.”).

B. The '505 Patent

The '505 patent relates to a method for recovering C3–C6 alcohols, specifically isobutanol, from dilute aqueous solutions, such as fermentation broths. Ex. 1001, Abstract; 8:25–27. The method includes culturing a microorganism in a fermentation medium to produce the alcohol. *Id.* at 4:63–65. The Specification discloses embodiments in which “[f]ermentation and recovery may be conducted simultaneously.” *Id.* at 8:27–28. For example, the method includes distilling a portion of the fermentation medium to produce a vapor phase that includes water and the alcohol, and returning the liquid phase to the fermentor. *Id.* at 4:67–5:12. The method further includes condensing the vapor phase to form an alcohol-rich liquid phase and a water-rich liquid phase, and then separating the liquid phases. *Id.* at 5:12–23. “Separation of the phases can be accomplished in various unit operations including liquid-liquid separators” *Id.* at 17:33–35. Recovery during fermentation, according to the '505 patent, improves fermentation volumetric productivity and reduces the required energy. *Id.* at 8:28–33.

Claim 1 is the sole independent claim in this trial. It reads:

1. A method for producing isobutanol comprising:
 - (a) culturing a microorganism capable of producing isobutanol in a fermentor, thereby forming a fermentation broth comprising microorganisms and isobutanol;
 - (b) removing a portion of the fermentation broth from the fermentor;
 - (c) distilling the portion, thereby forming an isobutanol-depleted liquid phase and an isobutanol-enriched vapor phase comprising water and isobutanol;

(d) condensing the isobutanol-enriched vapor phase formed in step (c), thereby forming an isobutanol-rich liquid phase and a water-rich liquid phase; and
(e) separating the isobutanol-rich phase liquid from the water-rich liquid phase using a liquid-liquid separator;
wherein:

- (1) said steps (b)–(e) are conducted simultaneously with step (a);
- (2) the isobutanol-depleted liquid phase comprises viable microorganisms; and
- (3) the isobutanol-depleted liquid phase is returned to the fermentor.

C. Reviewed Grounds of Unpatentability

The Board instituted trial on the following grounds of unpatentability:

Claims Challenged	Basis	References
1, 9, 10, and 13–17	§ 103	English ¹ and D’Amore ²
2–8, 11, 12, and 18	§ 103	English, D’Amore, and Bramucci ³
1, 9, 10, and 13–17	§ 103	Maiorella, ⁴ Hess, ⁵ and D’Amore
2–8, 11, 12, and 18	§ 103	Maiorella, Hess, D’Amore, and Bramucci

¹ English et al., U.S. Patent No. 4,349,628 (Ex. 1002) (“English”).

² D’Amore et al., U.S. Patent Pub. No. 2008/0132741 A1 (Ex. 1003) (“D’Amore”).

³ Bramucci et al., U.S. Patent Pub. No. 2008/0124774 A1 (Ex. 1004) (“Bramucci”).

⁴ B. L. Maiorella et al., *Biotechnology Report Economic Evaluation of Alternative Ethanol Fermentation Processes*, 26 BIOTECHNOLOGY AND BIOENGINEERING 1003 (1984) (Ex. 1005) (“Maiorella”).

⁵ Glenn Hess, *BP and DuPont Plan ‘Biobutanol,’* CHEMICAL & ENGINEERING NEWS, June 26, 2006, at 9 (Ex. 1006) (“Hess”).

II. ANALYSIS

A. *Real-Party-in-Interest Analysis*

A petitioner for an *inter partes* review must identify all real parties in interest. 35 U.S.C. § 312(a)(2); *see also* 37 C.F.R. § 42.8(b)(1). Whether a non-party is a real party in interest is a highly fact-dependent question. Office Patent Trial Practice Guide (“Trial Practice Guide”), 77 Fed. Reg. 48,756, 48,759 (Aug. 14, 2012). One factor in such inquiry is whether the non-party “exercised or could have exercised control over a party’s participation in a proceeding.” *Id.*

Gevo argues that E.I. Dupont de Nemours and Co. (“DuPont”) is a real party in interest. PO Resp. 31–32. Butamax is a joint venture of DuPont and BP Biofuels North America LLC (“BP”). Ex. 2001, 1. Gevo emphasizes that Butamax and DuPont are the only two co-plaintiffs in a district court action seeking a declaration of non-infringement of the ’505 patent. PO Resp. 31–32. This fact, Gevo argues, demonstrates that DuPont has an interest in invalidating the ’505 patent. *Id.* This fact also, according to Gevo, distinguishes this proceeding from the one the Board cited in the Decision to Institute, U.S. Patent No. 6,374,180, Reexamination Control No. 95/001,852 (Dec. 13, 2011). Dec. 3–4. In that proceeding, Gevo points out, two co-defendants in related litigation were asserted to be real parties in interest, in contrast to the present proceeding in which Butamax and DuPont are co-plaintiffs. PO Resp. 32. Gevo’s arguments are unpersuasive.

Gevo correctly asserts that “at a general level, the ‘real party-in-interest’ is the party that desires review of the patent.” *Id.* at 31 (quoting Trial Practice Guide, 77 Fed. Reg. at 48,759). But this does not mean that *any* party that desires review of a patent is a real party in interest. After all,

any entity intending to develop isobutanol as biofuel may have an interest in the validity of the '505 patent. Such a desire, however, is not determinative in the real-party-in-interest analysis.

Butamax and DuPont asserted in the declaratory judgment complaint that they sought the declaration because Gevo sued them as co-defendants for allegedly infringing the parent of the '505 patent. Ex. 2005 ¶¶ 10–12. Viewed in this context, DuPont being a co-plaintiff with Butamax in a civil action does not demonstrate that DuPont does or is able to exercise control over Butamax in this *inter partes* review proceeding. It also does not serve as a basis to effectively distinguish the reexamination decision the Board cited in the Decision to Institute.

Gevo's other evidence and arguments similarly fall short of establishing DuPont as a real party in interest. Gevo argues that Butamax "is wholly owned by DuPont and BP, and thus, funding for the present proceeding necessarily originated from the parent entities." PO Resp. 32. But Gevo does not contend that BP is a real party in interest; nor does it present credible evidence to demonstrate that funding for this *inter partes* review necessarily comes from DuPont, not from BP.

Further, Gevo emphasizes that two members of Butamax's board of directors also serve as directors at DuPont. Exs. 2002–04. Gevo, however, does not assert that Butamax's board of directors includes only these two members or that these two members wield such authority as to influence the board's action. Without more information, these two member's service at DuPont also does not prove that DuPont controls or has the ability to control Butamax in this proceeding.

Gevo has not presented sufficient evidence to demonstrate that DuPont controls or could control Butamax in this proceeding. On this record, we are not convinced that DuPont is a real party in interest in this proceeding.

B. Claim Construction

In an *inter partes* review, the Board interprets a claim term in an unexpired patent according to its broadest reasonable construction in light of the specification of the patent in which it appears. 37 C.F.R. § 42.100(b). Under this standard, we assign claim terms their ordinary and customary meaning, as understood by a person of ordinary skill in the art, in the context of the entire patent disclosure. *See In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007). Here, the parties do not propose and we see no need for any express claim construction.

C. Unpatentability Analysis

Obviousness is a question of law based on underlying facts. *Graham v. John Deere Co. of Kansas City*, 383 U.S. 1, 17–18 (1966). The factual components include the scope and content of the prior art, the differences between the prior art and the claimed invention, the level of skill in the art, and any objective evidence of nonobviousness. *Id.* at 17.

1. Testimonial Evidence

Butamax relies on the declaration of Dr. Andrew J. Daugulis (Ex. 1007, “Daugulis Declaration”) to support the Petition. Gevo relies on the declaration of Dr. Angelo Lucia (Ex. 2021) to support the Patent

Owner's Response. The parties also cite excerpts of the deposition transcripts of Dr. Lucia (Ex. 1017) and Dr. Daugulis (Ex. 2020) to support their respective positions.

In relation to its real-party-in-interest argument, Gevo contends that because Dr. Daugulis receives funding from DuPont, "his objectivity is suspect." Tr. 11:23–12:5. Substantively, Gevo asserts that some opinions presented in the Daugulis Declaration are unsupported by underlying data. PO Resp. 6. Gevo also argues that portions of Dr. Daugulis's deposition testimony "reflect a misunderstanding of the fundamental differences in separation methodologies between homogeneous mixtures (*e.g.*, ethanol-water) and heterogeneous mixtures (*e.g.*, isobutanol-water)." *Id.* at 7. As a result, according to Gevo, Dr. Daugulis's analysis and opinions regarding the cited references are not credible. *Id.* at 11. Butamax disputes these allegations. Reply 9–13.

Despite making these arguments, Gevo does not seek to disqualify Dr. Daugulis. *See, e.g.*, Tr. 12:12–15. Thus, we note Gevo's contentions, but shall consider and assign appropriate weight to the Daugulis Declaration and his deposition testimony.

2. Level of Skill in the Art

The parties agree that one skilled in the art would have a Ph.D. in chemical engineering and would have experience in distillation or fermentation and/or alcohol production. Ex. 1007 ¶ 16; Ex. 2021 ¶ 7.

3. Technical Background

There are four isoforms of butanol: 1-butanol (also known as *n*-butanol), 2-butanol, isobutanol, and tert butyl alcohol. Ex. 2024 § 7.1. Almost a century ago, the ABE (acetone, butanol, and ethanol) fermentation process was developed to produce 1-butanol. *Id.* When used as a biofuel, 1-butanol has several advantages over ethanol. *Id.* For example, butanol has higher energy density than ethanol, which translates into more range for a given volume fuel tank on a vehicle. *Id.* Unlike ethanol, which forms a homogenous azeotrope with water, however, 1-butanol and water form a heterogeneous azeotrope at atmospheric pressure. *Id.* As a result, separating 1-butanol from water cannot be achieved in a single distillation column. *Id.*

Isobutanol, like 1-butanol, also forms a heterogeneous azeotrope with water. Ex. 1014 ¶ 183.⁶ Because of this, at the time of the '505 patent invention, it was known that distillation can only separate the isobutanol-water mixture up to its azeotropic composition. *Id.* To isolate and purify isobutanol, distillation may be used in combination with another separation method, such as decantation or liquid-liquid extraction. *Id.* Specifically:

The isobutanol-water mixture forms a heterogeneous azeotrope so that distillation may be used in combination with decantation to isolate and purify the isobutanol. In this method, the isobutanol containing fermentation broth is distilled to near the azeotropic composition. Then, the azeotropic mixture is condensed, and the isobutanol is separated from the fermentation medium by decantation.

Id. ¶ 184.

⁶ Ex. 1014 (Donaldson et al., U.S. Patent Appl. Pub. No. 2007/0092957 A1) was published on April 26, 2007, before the earliest priority date of the '588 patent.

4. Prior Art

English (Ex. 1002)

English, titled “Fermentation Process for the Manufacture of an Organic Compound,” relates to “a process for the manufacture of ethanol or a similar volatile organic compound by the fermentation of a carbohydrate with a micro-organism.” Ex. 1002, 1:6–9. According to English, the fermentation product, once it reaches certain concentration, “exhibits a toxic effect on the micro-organism which is responsible for its production.” *Id.* at 1:19–22. To solve this issue, English teaches a process that includes, concurrent with fermentation, the steps of

continuously transferring a portion of the fermentation medium to a separator where ethanol or the like volatile organic compound is evaporated from the fermentation medium at a temperature which is not deleterious to the micro-organism by subjecting the fermentation medium to a reduced pressure and recycling part or all of the remaining fermentation medium to the fermenter.

Id. at 1:63–2:2.

In one embodiment, English discloses: (1) a prepared feedstock containing fermentable sugars is fed into a continuous fermentor where the sugars are fermented to produce ethanol; (2) a stream of the contents of the fermentor, typically containing 6% wt/wt ethanol, is withdrawn and introduced into a separator or flash vessel; (3) a mixture of vapors, generally containing about 40% wt/wt ethanol, is evaporated under reduced pressure in the separator and then subject to further recovery to reach 96–98% wt/wt ethanol; and (4) the remaining fluid in the separator is recycled to the fermentor. *Id.* at 7:33–8:36.

English states that its method can be used for manufacturing not only ethanol, but also other alcohols, including specifically, butanol, “from appropriate feedstocks using suitable micro-organisms.” *Id.* at 3:66–4:4.

D’Amore (Ex. 1003)

D’Amore teaches that isobutanol can be produced fermentatively by recombinant microorganisms. Ex. 1003 ¶¶ 23, 56. It also discloses several methods of separating isobutanol and water, including distillation. *See, e.g., id.* ¶¶ 39–45. Figure 2 of D’Amore illustrates an embodiment of the distillation method:

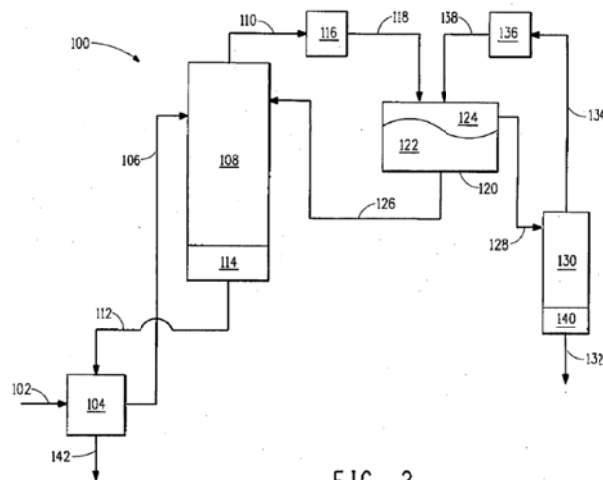


FIG. 2

Figure 2 shows fermentation broth stream 102 is introduced into beer column 108, where an isobutanol-enriched vapor phase is separated from isobutanol-depleted hot water stream 112. *Id.* ¶ 57. In condenser 116, the isobutanol-enriched vapor phase, introduced as overhead stream 110, is condensed into biphasic liquid stream 118, conducted into decanter 120, and separated into isobutanol-rich phase 124 and water-rich phase 122. *Id.* Isobutanol-rich phase 124 is sent to distillation column 130 where isobutanol is recovered as product stream 132. *Id.* Water-rich phase 122, which

contains 94% by weight water and 6% by weight isobutanol, is recycled to beer column 108. *Id.*

Bramucci (Ex. 1004)

Bramucci discloses that butanol toxicity to the host microorganism used in the fermentation limits the production of butanols. Ex. 1004 ¶ 5. It teaches butanol-tolerant microorganisms that grow in 2.4% w/v isobutanol. *Id.* ¶ 82.

Maiorella (Ex. 1005)

Maiorella describes several alternative fermentation schemes for ethanol production. Ex. 1005, Abstract. It discloses that “[f]or selective ethanol removal processes, the fermenting beer is cycled through a selective ethanol recovery device (membrane separator, extractor, or flash vessel) to recover a concentrated ethanol product for distillation and an ethanol depleted beer for recycle to the fermentor.” *Id.* at 1005 (citations omitted); *see also id.* at 1015, Fig. 17. Maiorella teaches sending clarified dilute beer to a stripper column to recover ethanol. *Id.* at 1005. According to Maiorella, recycling the microorganism cells to the fermentor “increases productivity and reduces costs.” *Id.* at 1010.

Hess (Ex. 1006)

According to Hess, 1-butanol, used as a biofuel, has several advantages over ethanol. Ex. 1006. Because “butanol is produced using a fermentation process very similar to that of ethanol,” Hess announces a plan to convert an ethanol plant to produce 1-butanol. *Id.*

5. Obviousness of Claims 1, 9, 10, and 13–17 over English and D’Amore

Butamax argues that claims 1, 9, 10, and 13–17 would have been obvious over the combination of English and D’Amore. Pet. 11–26.

For claim 1, Butamax points out that both English and D’Amore teach producing alcohol—ethanol-like volatile compounds, including butanol in English, and isobutanol in D’Amore—by culturing microorganisms in a fermentation medium. *Id.* at 17. Thus, according to Butamax, a skilled artisan “would have had a reasonable expectation of successfully culturing the microorganisms of D’Amore to produce isobutanol in the fermentation method of English (claim 1; step (a)).” *Id.* In addition, Butamax contends that English teaches steps (b), (c), and steps (1), (2), and (3) of the wherein clause (*id.* at 13–19); and D’Amore teaches steps (d) and (e) (*id.* at 14, 19–20). Butamax argues that based on the combination of English and D’Amore, one skilled in the art would have arrived at an isobutanol recovery process that includes every limitation of claim 1. *Id.* at 21.

Claims 9 and 10 depend from claim 1 and further specify that the isobutanol-rich liquid phase of step (d) has a ratio of isobutanol to water of greater than about 2 or greater than about 8, respectively. Claim 13 depends from claim 1 and further requires “cooling the isobutanol-rich liquid phase, thereby increasing the ratio of isobutanol to water in the isobutanol-rich liquid phase.” Dr. Daugulis, Butamax’s expert, testified that “[d]istillation was routine in the art” (Ex. 1007 ¶ 57), and that a skilled artisan “would have sought to obtain an isobutanol-rich liquid phase that was as pure as possible” (*id.* ¶ 56). Butamax also directs our attention to D’Amore’s teaching that the concentration of water in the isobutanol-rich liquid phase

varies with condensation temperature. Pet. 22 (citing Ex. 1003 ¶ 39). Butamax asserts that it would have required no more than routine optimization to obtain the isobutanol-to-water ratio recited in claims 9 and 10. *Id.* (citing Ex. 1007 ¶ 57). Further, Butamax argues that one skilled in the art would have had a reason and a reasonable expectation of success to cool the isobutanol-rich liquid in order to increase the ratio of isobutanol to water in the isobutanol-rich liquid, as recited in claim 13. Pet. 24 (citing Ex. 1007 ¶ 58).

Claims 14–16 depend from claim 1 and further specify the distillation temperature. Butamax first points to English where it teaches heating the fermentation broth with the goal to facilitate distillation but avoid rendering the microorganisms inactive. *Id.* at 25 (citing Ex. 1002, 4:26–33). According to Butamax, in an embodiment of English, the temperature of the fermentation broth is 40° C, which falls within the ranges specified in claims 14–16. *Id.* (citing Ex. 1002, 7:50–60). Recognizing that the embodiment of English discusses producing ethanol, while claims 14–16 are directed to producing isobutanol, Butamax argues that one skilled in the art would have had a reason to optimize the distillation temperature to achieve the same goal set forth in English, i.e., facilitate distillation but avoid rendering the microorganisms inactive. *Id.* Because it would have taken routine optimization to arrive at the claimed temperature ranges, Butamax further contends, claims 14–16 would have been obvious. *Id.* at 26.

Claim 17 depends from claim 1 and further requires that the distillation is carried out at a reduced pressure. Butamax points out that English teaches distilling ethanol or a like volatile organic compound at a reduced pressure. *Id.* (citing Ex. 1002, 1:64–68). Thus, Butamax argues,

when producing isobutanol using the method based on the combined teachings of English and D'Amore, one skilled in the art would have had a reason to distill at a reduced pressure. *Id.* (citing Ex. 1007 ¶ 62).

Gevo does not dispute that the combination of English and D'Amore teaches or suggests all the claim limitation of claims 1, 9, 10, and 13–17. *See* Ex. 1017, 61:25–71:1. Instead, Gevo argues that one skilled in the art would have had no reason to combine the references and that the combination of the references would render English unsuitable for its intended purposes. PO Resp. 33–51.

According to Gevo, “processes for obtaining high purity alcohol from homogeneous mixtures (ethanol-water) and heterogeneous mixtures (isobutanol-water) are fundamentally different.” *Id.* at 39. Gevo’s expert, Dr. Lucia, testified that the processes disclosed in English are “only suitable for separating homogeneous azeotropes like ethanol and water.” Ex. 2021 ¶ 62; *see also* PO Resp. 33. Because isobutanol forms a heterogeneous azeotrope with water, Gevo asserts, one skilled in the art would not look to English as a starting point to produce isobutanol. PO Resp. 39–44. Even if English was selected as a starting point, Gevo further argues, a skilled artisan would not disregard English’s stated objective to save energy by modifying English’s process with D'Amore. *Id.* at 41, 44–45.

We find Gevo’s argument unconvincing. First, the test for obviousness is whether the claimed invention is rendered obvious by the teachings of the prior art as a whole. *In re Etter*, 756 F.2d 852, 859 (Fed. Cir. 1985) (en banc). Here, we analyze the combined teachings of English and D'Amore; it matters not whether one skilled in the art would look to

English as a starting point or to supplement the teachings of D'Amore. *See In re Bush*, 296 F.2d 491, 496 (CCPA 1961).

Second, as Butamax correctly points out, English never uses the terms “homogeneous” or “azeotrope.” Reply 3. Instead, English specifically teaches that its method can be used for manufacturing butanol from fermentation. Ex. 1002, 3:47–52; 3:66–4:4. In his declaration, Dr. Lucia states that the butanol in English is t-butanol because it forms a homogeneous azeotrope with water. Ex. 2021 ¶ 50. During his deposition, however, Dr. Lucia testified that he was not certain which butanol is produced through the fermentation process. Ex. 1017, 12:4–24. In fact, the isoform of butanol produced by ABE fermentation is 1-butanol, which forms a heterogeneous azeotrope with water. Ex. 2024 § 7.1. Thus, contrary to Gevo's assertion, English does not limit “ethanol like volatile organic compounds” to only those that form homogeneous azeotropes with water.

Third, D'Amore teaches that “1-Butanol and isobutanol share many common features that allow the separation schemes devised for the separation of 1-butanol and water to be applicable to the isobutanol and water system.” Ex. 1003 ¶ 37. During his deposition, Dr. Lucia confirms that the separation processes for recovering isobutanol and 1-butanol from fermentation broth “would be roughly the same.” Ex. 1017, 85:13–86:4. Thus, it appears reasonable for one skilled in the art, when designing a process to produce isobutanol, to consult prior art disclosing processes to produce 1-butanol. This is especially so here because D'Amore, while recognizing fermentation methodology as “well known in the art” (Ex. 1003 ¶ 34; *see also id.* ¶ 36), does not describe the fermentation process in detail. English, on the other hand, teaches fermentation processes that can be used

to produce 1-butanol. *See, e.g.*, Ex. 1002, 7:33–8:36. Thus, we are persuaded that one skilled in the art having the goal of fermenting biomass to produce isobutanol would have had a reason to combine the teachings of English and D’Amore.

In addition, Gevo argues that Dr. Daugulis, Butamax’s expert, conceded during his deposition that one skilled in the art would not combine English and D’Amore. PO Resp. 46 (citing Ex. 2020, 147:15–21). We do not find this argument persuasive. Even though he stated that it may be better to have additional equilibrium stages, Dr. Daugulis testified that “a simple isobutanol process could operate with [a] flash unit.” Ex. 2020, 147:15–17; 148:6–7.

Gevo next argues that combining English and D’Amore would change the fundamental principles of operation of the English process. PO Resp. 47–49. As explained above, we are not sufficiently persuaded that the basic principle of operation of English is limited to only homogeneous azeotrope production. Thus, we do not find the combination of English and D’Amore would have changed the principle of operation of English.

Gevo also contends that combining English and D’Amore would render English unsuitable for its intended purpose of purifying ethanol to a purity of 96–98%. PO Resp. 47–49. This argument also is inapposite. To analyze whether the challenged claims would have been obvious, we inquire whether one skilled in the art, combining the teachings of English and D’Amore, would have been successful in designing a method to produce isobutanol. It is irrelevant whether such a method can be used to purify ethanol.

Further, Dr. Lucia emphasizes the economic impact that would result from any modification of the English processes. Ex. 2021 ¶ 53. Relying on Dr. Lucia’s opinion, Gevo asserts that without “significant simulation and economic analysis,” it would be “impossible” for a skilled artisan to conclude “whether such a modified process could be considered ‘successful.’” PO Resp. 44–45 (citing Ex. 2021 ¶¶ 69, 70); *see also id.* at 34–35. Gevo’s argument is unconvincing. Dr. Lucia’s expressed skepticism is directed to the economic feasibility—whether the modified process could be considered *commercially* successful—not the technical merit of the claimed invention. But commercial viability does not control the obviousness determination:

[T]he fact that the two [prior art disclosures] would not be combined by businessmen for economic reasons is not the same as saying that it could not be done because skilled persons in the art felt that there was some technological incompatibility that prevented their combination. Only the latter fact is telling on the issue of nonobviousness.

Orthopedic Equip. Co., Inc. v. United States, 702 F.2d 1005, 1013 (Fed. Cir. 1983). Therefore, we are not persuaded that economic analysis is required for the obviousness analysis.

Finally, Gevo contends that Butamax improperly relies on hindsight in asserting obviousness of the challenged claims. PO Resp. 49. D’Amore discloses, in addition to distillation, several other methods to purify isobutanol, including pervaporation, gas stripping, adsorption, and liquid-liquid extraction. Ex. 1003 ¶¶ 41–45. Gevo argues that none of those methods, when combined with English, could arrive at the claimed invention. PO Resp. 49; *see also* IPR2013-00214 Tr. 49:9–51:22.

According to Gevo, Butamax's selection of only distillation, while ignoring the other methods, for combination with English, is based on the hindsight knowledge of the claimed invention. PO Resp. 49. 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 D'Amore, which explicitly teaches distillation to recover isobutanol from fermentation broth. Ex. 1003 ¶¶ 39, 40. D'Amore's teaching of other recovery methods does not render the combination of this method with the teaching of English not obvious. Indeed, during his deposition, Dr. Lucia testified that "the usual strategy" to purify a compound that forms a

heterogeneous azeotrope with water would be to separate the condensed biphasic vapor with a decanter after distillation. Ex. 1017, 58:6–13.

In sum, we determine Butamax has shown that the combination of English and D’Amore teaches or suggests all the limitations of claims 1, 9, 10, and 13–17. In addition, one skilled in the art would have had a reason to combine these two references and would have had a reasonable expectation that the modified method would be successful in producing isobutanol. Therefore, Butamax has shown by a preponderance of the evidence that claims 1, 9, 10, and 13–17 would have been obvious over the combination of English and D’Amore.

6. Obviousness of Claims 2–8, 11, 12, and 18 over English, D’Amore, and Bramucci

Butamax argues that claims 2–8, 11, 12, and 18 would have been obvious over the combination of English, D’Amore, and Bramucci. Pet. 27–34.

Claims 2–8 depend from claim 1 and further specify that the isobutanol-enriched vapor phase has an isobutanol concentration at least about 5-, 10-, 11-, 12-, 13-, 14-, and 15-fold, respectively, greater than the concentration of the portion of the fermentation broth. Claims 11 and 12 depend from claim 1 and further specify that the ratio of isobutanol to water in the isobutanol-rich liquid phase is greater than the ratio of isobutanol to water in the fermentation broth by at least 5- and 25-fold, respectively.

Butamax refers to English, D’Amore, and Bramucci for teaching the limitation of butanol production due to butanol toxicity to the host microorganism during fermentation. Pet. 28 (citing Ex. 1002, 1:19–22;

Ex. 1003 ¶ 29; Ex. 1004 ¶ 5). According to Butamax, a skilled artisan would have had a reason to optimize the fermentation and recovery conditions in order to maintain a low level of isobutanol in the fermentation broth to prevent toxicity. *Id.* In addition, Bramucci discloses microorganisms that grow in 2.4% w/v isobutanol (Ex. 1004 ¶ 82), and D’Amore discloses a vapor phase composition of 67% by weight isobutanol (Ex. 1003 ¶ 38). Butamax argues that “[a]chieving 67% by weight isobutanol in the isobutanol-enriched vapor phase from a fermentation broth having 2.4% by weight isobutanol” satisfies the additional limitations of claims 2–8, 11, and 12. Pet. 29.

Claim 18 depends from claim 1 and further recites:

- [a] the distilling is carried out at a reduced pressure compared to the pressure of the fermentor, and at a temperature ranging from about 35° C. to about 95° C.;
- [b] the isobutanol-enriched vapor phase comprises an azeotrope of isobutanol and water;
- [c] the isobutanol-enriched vapor phase has an isobutanol concentration at least about 5-fold greater than the isobutanol concentration of the portion of the fermentation broth; and
- [d] the isobutanol-rich liquid phase has a ratio of isobutanol to water of greater than about 8.

Butamax argues that English teaches limitation [a] as discussed in relation to claims 16 and 17. Pet. 31. For limitations [c] and [d], Butamax advances the same arguments as those in relation to claims 2 and 9, respectively. *Id.* at 33–34. For limitation [b], Butamax contends that Gevo uses the term “azeotrope” to describe the vapor from flash tank 34 of Figure 2 of the challenged patent. *Id.* at 31 (citing Ex. 1001, 25:27–36). According to Butamax, the flash tank of English, when modified to produce isobutanol,

operates under conditions similar to flash tank 34. *Id.* Butamax asserts that a skilled artisan would have had a reason to optimize the temperature and pressure conditions of distillation so that the vapor from the flash tank of English satisfies limitation [b]. *Id.* at 32.

Gevo does not address Butamax's arguments that English, D'Amore, and Bramucci teach or suggest each limitation. Instead, Gevo contends that this ground is defective for the same reasons discussed above in relation to the ground based on English and D'Amore only. PO Resp. 51. In addition, Gevo argues that because Bramucci fails to remedy the deficiencies of English and D'Amore, the combination of the three references would not render claim 1 and claims dependent therefrom obvious. *Id.*

As explained in Section II.C.3, we determine Butamax has met its burden in demonstrating claim 1 obvious over the combination of English and D'Amore. In addition, Butamax points to English, D'Amore, and Bramucci as teachings or suggesting the additional limitations in claims 2–8, 11, 12, and 18, and we are persuaded by Butamax's showing as to these additional limitations. We are also persuaded that one skilled in the art would have had a reason to combine the teachings of these references. Therefore, Butamax has established by a preponderance of the evidence that claims 2–8, 11, 12, and 18 would have been obvious over the combination of English, D'Amore, and Bramucci.

7. Obviousness of Claims 1, 9, 10, and 13–17 over Maiorella, Hess, and D'Amore

Butamax argues that claims 1, 9, 10, and 13–17 would have been obvious over the combination of Maiorella, Hess, and D'Amore. Pet. 35–

49. Butamax's arguments supporting this ground are similar to those addressing the ground based on the combination of English and D'Amore, with Maiorella's teachings replacing those supplied in English. *Id.*

Gevo does not address Butamax's arguments that Maiorella, Hess, and D'Amore teach or suggest each limitation. Instead, Gevo asserts that Maiorella discloses processes for producing ethanol (a homogeneous azeotrope), which would not be "commercially suitable" for purifying isobutanol (a heterogeneous azeotrope). PO Resp. 53. We are not persuaded. As Butamax points out, Hess teaches modifying an ethanol plant to produce 1-butanol. Pet. 41 (citing Ex. 1006). D'Amore teaches and Dr. Lucia confirms that because 1-butanol and isobutanol share many common features, the separation schemes for the two are "roughly the same." Ex. 1017, 85:13–86:4; *see also* Ex. 1003 ¶ 37. Thus, we are persuaded that one skilled in the art reading Maiorella, Hess, and D'Amore would have had a reason to modify Maiorella's process to produce isobutanol.

Also, similar to its arguments presented in relation to the ground based on the combination of English and D'Amore, Gevo again (1) emphasizes the lack of economic considerations; and (2) contends that modifying a process designed to purify ethanol to purify isobutanol would render the process inoperable and unsuitable for its intended purpose. PO Resp. 52–54. We are unconvinced by either argument for the same reasons we explained above in addressing the ground based on the combination of English and D'Amore.

In sum, we determine that Butamax has shown by a preponderance of the evidence that claims 1, 9, 10, and 13–17 would have been obvious over the combination of Maiorella, Hess, and D'Amore.

8. Obviousness of Claims 2–8, 11, 12, and 18 over Maiorella, Hess, D’Amore, and Bramucci

Butamax argues that claims 2–8, 11, 12, and 18 would have been obvious over the combination of Maiorella, Hess, D’Amore, and Bramucci. Pet. 49–57. Butamax’s arguments supporting this ground are similar to those addressing the ground based on the combination of English, D’Amore, and Bramucci, with Maiorella’s teaching replacing those supplied in English. *Id.*

Gevo does not address Butamax’s arguments that Maiorella, Hess, D’Amore, and Bramucci teach or suggest each limitation. Instead, Gevo argues that because Bramucci fails to remedy the deficiencies of Maiorella, Hess, and D’Amore, the combination of all these references would not render claim 1 and claims dependent therefrom obvious. PO Resp. 55.

As explained in Section II.C.5, we determine Butamax has met its burden in demonstrating claim 1 obvious over the combination of Maiorella, Hess, and D’Amore. In addition, Butamax points to Maiorella, D’Amore, and Bramucci for teachings or suggestions of the additional limitations in claims 2–8, 11, 12, and 18, and we are persuaded by Butamax’s showing as to these additional limitations. We are also persuaded that one skilled in the art would have had a reason to combine the teachings of these references. Thus, we determine Butamax has established by a preponderance of the evidence that claims 2–8, 11, 12, and 18 would have been obvious over the combination of Maiorella, Hess, D’Amore, and Bramucci.

III. CONCLUSION

Butamax has shown by a preponderance of the evidence that claims 1–18 of the '505 patent are unpatentable.

IV. ORDER

Accordingly, it is

ORDERED that claims 1–18 of the '505 patent are determined to be UNPATENTABLE; 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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Patent 8,283,505 B2

For PETITIONER:

Deborah A. Sterling
Peter A. Jackman
STERNE, KESSLER, GOLDSTEIN & FOX PLLC
pjackman-PTAB@skgf.com
dsterlin-PTAB@skgf.com

For PATENT OWNER:

Thomas A. Blinka, Ph.D.
William E. Brow, Ph.D.
COOLEY LLP
tblinka@cooley.com
wbrow@cooley.com
IPR2013-00215@cooley.com