

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SYMRISE AG and SYMRISE INC.,
Petitioners,

v.

INOLEX INVESTMENT CORP.,
Patent Owner.

IPR2023-01035
U.S. Patent No. 10,995,048

THIRD DECLARATION OF MICHAEL E. WRIGHT, Ph.D.

I, Michael E. Wright, Ph.D, declare and state as follows:

1. I am the same Michael E. Wright who submitted Declarations dated February 7, 2024 (hereinafter, my “First Declaration”) and June 13, 2024 (hereinafter, my “Second Declaration”), in this proceeding on behalf of Patent Owner, Inolex Investment Corp. (“Inolex” or “Patent Owner”) in support of the patentability of substitute claims 29-44 of U.S. Patent No. 10,995,048 (“the ’048 patent,” **Ex. 1001**).

2. The opinions and conclusions I express in this declaration are based on my education, my extensive experience in the fields of heterogeneous catalysis, homogeneous catalysis, organic and organometallic synthesis, and my review of materials related to this matter.

3. My Qualifications set forth in my First Declaration (**Ex. 2001**) have not changed and are incorporated herein by reference.

4. I still have no financial interest in the outcome of this proceeding and am not being compensated for my time spent working on this matter. In contrast, even prior to preparing his Third Declaration, Dr. Taber had been paid approximately \$40,000 by Symrise for his work on this matter. **Ex. 2007**, p. 139, l. 20 – p. 140, l. 6.

I. MATERIALS REVIEWED

5. In forming my opinions set forth herein, I reviewed, among other things Petitioners' Opposition to Patent Owner's Revised Non-Contingent Motion to Amend (Paper 20), as well as the First, Second, and Third Declarations of Douglass F. Taber (**Ex. 1002**, **Ex. 1038**, and **Ex. 1046**) and the materials referenced therein (including, but not limited to **Ex. 1007-Ex. 1013**, **Ex. 1020-Ex. 1037**, **Ex. 1039-Ex. 1045**, and **Ex. 1047-Ex. 1049**). I also reviewed materials from IPR2023-01439 that are referenced in Dr. Taber's Third Declaration, including U.S. Patent No. 10,882,803. I also reviewed my First and Second Declarations (**Ex. 2001** and **Ex. 2006**) and the following materials:

Materials Reviewed	
Ex. 2002	J. Ross, "Heterogeneous Catalysis," Elsevier B.V. (2012)
Ex. 2003	Kim <i>et al.</i> , "Dual-bed catalytic system comprising Al ₂ O ₃ and Ba/Al ₂ O ₃ with enhanced 1-octene productivity in 1-octanol dehydration for linear α -olefin production," <i>J. Ind. Eng. Chem.</i> 119:376-85 (2023) (" <i>Kim</i> ")
Ex. 2004	Experimental data generated by Inolex, Inc. for the conversion of 1-octanol to octenes
Ex. 2005	Deposition Testimony of Douglass F. Taber, January 23, 2024
Ex. 2007	Deposition Testimony of Douglass F. Taber, June 11, 2024
Ex. 2008	Int'l Patent Pub. No. WO 2022/122139 A1 (" <i>Bugdahn</i> ")
Ex. 2009	D.J. Ward <i>et al.</i> , "Sustainable routes to alkenes: applications of homogeneous catalysis to the dehydration of alcohols to alkenes," <i>Catal. Sci. Technol.</i> 13:2638-2647 (2023) (" <i>Ward</i> ")

II. U.S. PATENT NO. 10,995,048

6. While discussed in my First and Second Declarations, I note that the methods disclosed in the '048 patent for dehydrating bio-1-alcohols, and in particular, bio-1-octanol, to provide corresponding bio-1-alkenes with high-regioselectivity and a high alcohol conversion do so in a single pass through an isothermal fixed bed (or similar) chemical reactor. For example, the '048 patent teaches that:

The reactor can be designed as a simple heated reaction tube packed with catalyst and a flow of the gaseous bio-1-alcohol over the catalyst, preferably in a single pass affording greater than about 95% conversion, with greater than about 98% a preferred embodiment, and in all cases with no recycle stream used whatsoever in the overall process flow.

Ex. 1001, col. 15, ll. 27-32 (emphasis added). In my opinion, this is particularly notable and entirely unexpected given the general disclosures in the prior art. Specifically, none of the prior art of record in this proceeding teaches, demonstrates, or suggests a process capable of dehydrating a C₆ to C₁₀ bio-1-alcohol to provide a bio-1-alkene in a conversion of at least 95% and a bio-1-alkene regioselectivity of 92% to about 99% using a constant flow and single pass reactor design. Furthermore, a long TOS also leads to a simple process flow scheme reducing energy use and natural resources (like gamma-alumina).

Avoiding use of excess energy to reheat a recycle stream is just one very significant advantage for the Inolex catalyst and process, and no recycle stream also eliminates the potential and reality of catalyst contamination from recycle impurities, assuring a simple and continuous production of, for example, bio-1-octene and greatly contributing to a favorable life cycle analysis (LCA) of energy and resource uses. These are the requirements for any and all truly sustainable chemical commercial processing units.

7. As the '048 patent teaches, this remarkable regioselectivity and conversion is provided by heating the bio-1-alcohol in a reactor with a γ -alumina catalyst treated with a calcium promoter and then calcined at a temperature of about 400 °C to about 480 °C. *See Ex. 1001* at pp. 22-23, col. 26, l. 10 – col. 27, l. 35 (Examples 1-5); *see also Ex. 1006* at pp. 578-59 of 719, ¶¶ [0121]-[0127]; *Ex. 1005* at pp. 38-40 of 236, ¶¶ [0121]-[0127]. Specifically, the '048 patent reports the use of a calcium promoter-treated and then calcined γ -alumina catalyst to dehydrate 1-hexanol and 1-octanol. In the case of 1-hexanol, a γ -alumina catalyst was first treated with a calcium acetate solution, followed by calcination in air at 440 °C for 12 hours. Dehydration reactions conducted at 330 °C and 350 °C provided conversion (to 1-, 2-, and 3-hexenes) of 96.3% and 96.9%, respectively,

with a regioselectivity for the formation of 1-hexene of 95.8%¹ and 96.8% (as reported in Table 5, below).

TABLE 5

Catalyst	Reactor Temperature (° C.)	1-Hexene (%)	2-Hexenes & 3-Hexene (%)	1-Hexanol (%)	1-Hexene Selectivity (%)
EXAMPLE 11A	330	92.8	3.5	1.8	95.8
EXAMPLE 11B	350	93.8	3.1	1.7	96.8
EXAMPLE 11C	370	90.1	3.2	1.6	96.6

Ex. 1001, col. 29, ll. 1-25 (Example 11); **Ex. 1006** at p. 62 of 719, ¶ [0133],

Ex. 1005 at p. 43 of 236, ¶ [0133].

8. Surprisingly, increasing the reactor temperature to 370 °C reduced conversion (to hexenes) to 93.3% (from 96.9% at 350 °C), while maintaining a regioselectivity of 96.6% (as shown in Table 5, above). This increase in leading to less conversion was unexpected, particularly in view of prior art calcium-promoted catalysts such as those disclosed in *Wright '451* that provide conversion (i.e. higher reactor temperature equals higher conversion) in excess of 95% at 380 °C. *See Ex. 1039*, Figs. 10-12.

9. In the case of 1-octanol, γ -alumina was first treated with a calcium acetate (i.e., promoter) solution, followed by calcination in air at 440 °C or 500 °C for 12 hours. Dehydration conducted at 315 °C provided conversion (to octenes) of

¹ I note that the calculation of 1-Hexene Selectivity for Example 11A in Table 5 appears to be incorrect and should be 96.4%.

97.2% and 95.5%, respectively, with a regioselectivity of 97.4%² and 93.1% (per Table 2, below). Thus, the '048 patent discloses that treatment with a calcium promoter followed by calcination was important to obtain the claimed conversion and bio-1-alkene regioselectivity. Further, while both catalysts far exceed any known catalyst performance, it is noteworthy that a higher calcination temperature led to a less selective catalyst. I am not aware of any prior art that discloses, let alone teaches or suggests such a low, and “capped” calcination temperature leading to a better performing catalyst. Thus, the '048 patent teaches that higher calcination temperatures can be detrimental to catalyst performance—a truly unexpected result.

TABLE 2

Catalyst	Calcination Temperature (° C.)	1-Octene (%)	2-Octene & 3-Octenes (%)	1-Octanol (%)	1-Octene Selectivity (%)
EXAMPLE 1	440	94.0	3.2	1.6	97.4
EXAMPLE 2	500	88.9	6.6	3.5	93.1

Ex. 1001, col. 26, l. 10 – col. 27, l. 9 (Examples 1-3); **Ex. 1006** at pp. 57-58 of 719, ¶¶ [0121]-[0125]; **Ex. 1005** at pp. 38-39 of 236, ¶¶ [0121]-[0125].

10. Examples 4 and 5 of the '048 patent disclose that a γ -alumina catalyst was first modified with an aqueous solution of calcium acetate to “deliver 1.50%

² I note that the calculation of 1-Octene Selectivity for Example 1 in Table 2 appears to be incorrect and should be 96.7%.

of CaO (after calcination)” in air at 440 °C for a period of 12 h. **Ex. 1001**, col. 27, ll. 10-18 (Example 4). The catalyst was placed in an insulated 75 mL reactor that was maintained at 315 °C, into which bio-1-octanol was fed at 0.2 mL/min. **Ex. 1001**, col. 27, ll. 20-28 (Example 5). The catalyst was removed from the reactor and photographed. The catalyst showed only minor discoloration, and notably, after 1400 h (~58 days) of TOS, conversion efficiency and 1-octene regioselectivity remained absolutely steady. *See* **Ex. 1001**, col. 29, ll. 26-35 (Example 12), Fig. 7; **Ex. 1006** at p. 62 of 719, ¶ [0135], Example 12, p. 79 of 719, Fig. 7; **Ex. 1005** at p. 40 of 236, ¶ [0135], Example 12, p. 54 of 236, Fig. 7. The bio-1-octanol was not dried nor were any precautions taken to remove silicon-containing compounds from the 1-octanol feedstock. *Compare* with **Ex. 1027** at pp. 149-50. In my opinion, a person of ordinary skill in the art (“POSITA”) would view the TOS achieved by the catalyst prepared in the ’048 patent as being entirely unexpected.

III. LEGAL STANDARDS

11. In forming my opinions set forth herein, I applied the legal standards set forth in my First Declaration, which are incorporated herein by reference, as well as the following legal standards that were explained to me.

A. Written Description

12. I have been informed and understand that to satisfy the “written description” requirement, the patent specification must reasonably convey to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date. This involves an objective inquiry into the four corners of the specification from the perspective of a POSITA. Based on that inquiry, the specification must describe an invention understandable to that skilled artisan and show that the inventor actually invented the invention claimed. I have also been informed that written description is a question of fact.

B. Indefiniteness

13. I have been informed and understand that a patent claim is invalid for indefiniteness if, when read in view of the specification and prosecution history, the claim would fail to inform, with reasonable certainty, those skilled in the art about the scope of the claimed invention. I have also been informed that indefiniteness is ultimately a question of law supported by underlying facts.

C. Anticipation

14. I have been informed and understand that a claimed process is anticipated where a single prior art reference describes the same invention as that which is claimed. That is, each and every element of the claim at issue must be disclosed within a single prior art reference in the same manner as recited in the

claim at issue (without the necessity for a POSITA to pick and choose or combine various aspects of a prior art disclosure).

D. Obviousness

15. I understand that a claim is invalid as obvious “if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a POSITA to which the claimed invention pertains.” 35 U.S.C. § 103. I understand that obviousness may be based on a combination of references, and that the combination of familiar elements according to known methods is likely obvious when it does no more than yield predictable results.

16. I also understand that an obviousness inquiry requires consideration of the following factors: (1) the scope and content of the prior art; (2) the differences between the claims and the prior art; (3) the level of ordinary skill in the pertinent art; and (4) any objective indicia of non-obviousness, such as unexpected results.

17. I understand that the obviousness analysis requires a comparison of the properly construed claim language to the prior art to determine whether the claimed subject matter as a whole would have been obvious.

18. It is my understanding that all prior art references are to be looked at from the viewpoint of a POSITA, and obviousness is analyzed from the

perspective of one of skill in the art at the time the invention was made. Thus, the use of hindsight is not permitted.

19. I also understand that a claimed invention can be obvious where, if a single reference does not disclose each limitation of a claim, the missing limitations would have been obvious to a POSITA based on his/her background knowledge and skill at the relevant time. I also understand that obviousness based on a combination of references does not require an explicit suggestion in any of the references to combine them, if, as a matter of skill or practice in the field it would be known to do so.

20. I understand that any objective indicia of non-obviousness, such as unexpected results, must be commensurate with the scope of the claims and that there in order to have relevance to the question of obviousness, an unexpected result must be attributable to, or have a “nexus” with, the claimed invention.

1. Obviousness of a Range

21. I have been informed that a prior art disclosure of a range, such as for example 200 to 600 °C, is no more a disclosure of the end points of the range than is of each of the intermediate points. In such instances, the relevant inquiry for a POSITA would be to look at specific temperatures that were used, for instance in working examples, in order to determine values in a range that were specifically disclosed.

22. I have been informed and understand that a process or process step that requires a range of values—for example, a temperature range—is generally considered obvious where prior art discloses a broader range that encompasses the claimed values or a range that overlaps with a portion of the claimed values. I also understand that, in such instances, the relevant inquiry in assessing the obviousness of a claimed range is to ask whether a POSITA would have been motivated to select the claimed range based on the prior art as a whole. I have been informed that, also relevant to this inquiry, it is necessary to assess whether there is evidence, for example, that: (1) the prior art taught away from the claimed range of values; or (2) the claimed range provides any new and unexpected results compared to the prior art.

23. I have been informed that a prior art reference is said to teach away when a POSITA, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the inventors. I am also informed that a reference does not teach away if it merely expresses a general preference for an alternative invention but does not criticize, discredit, or otherwise discourage investigation into the range or invention that is claimed.

24. I have also been informed that results provided by a claimed range are considered “unexpected” (and therefore probative of non-obviousness), where

there is a difference in kind, and not merely in degree, over the results provided by a prior art range.

2. Obvious to Try

25. I have been informed and understand that a process or process step may be “obvious to try” when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, and a POSITA has good reason to pursue those known options within his or her technical grasp. If this leads to the anticipated success, it is likely the product not of innovation but of ordinary skill and common sense.

E. Claim Construction

26. Dr. Taber’s Third Declaration does not specifically identify any additional claim terms requiring construction. I have offered the following constructions for the following claim terms:

Claim Term (Claim)	Proposed Construction
“a calcium-promoted γ -alumina catalyst calcined at a temperature of about 420 °C to about 480 °C” (Substituted Claim 29)	Plain and ordinary meaning, which is “a γ -alumina catalyst that has been modified by reacting with a Ca^{+2} compound.”
“a calcium-promoted γ -alumina catalyst calcined at a temperature of about 420 °C to about 480 °C.” (Substitute Claim 29)	Plain and ordinary meaning, which is a calcium-promoted γ -alumina catalyst that is then calcined at “a temperature of about 420 °C to about 480 °C.”
“from a single-pass reaction” (Substitute Claim 29)	Plain and ordinary meaning, which is “a single pass of the bio-1-alcohol through the specified continuous flow

	reactor.” This phrase excludes any affirmative steps of isolating unreacted bio-1-alcohol, ethers (and possible contaminants) from the effluent stream of the continuous flow reactor and recycling such effluents in a second pass through the reactor in order to attempt an apparent improvement of the overall conversion of bio-1-alcohol to bio-1-alkene.
“about” (Substitute Claims 29, 33, 34, 36, 37, 39, 40, 42, and 43).	Plain and ordinary meaning, which is “approximately.” In the context of a specified temperature this would include deviations of a few degrees centigrade, and at most, plus or minus five degrees centigrade from a specified temperature.

27. I note that, Dr. Taber alleges that the phrase “heating the bio-1-alcohol in a continuous flow reactor at a temperature of 240 °C to 360 °C,” which appears in substitute claim 29, has two possible meanings that are allegedly incompatible with one another and thereby render this claim indefinite. **Ex. 1046**, ¶¶34-38. As discussed below, I disagree with Dr. Taber’s analysis and conclusions concerning this claim term, and, in the event that the PTAB believes that this claim term requires construction, then in my opinion this term should be construed to have its plain and ordinary meaning as understood by a POSITA, which is “heating the bio-1-alcohol in a continuous flow reactor that has been adjusted to a temperature in the range of 240 °C to 360 °C.”

28. In my opinion, a POSITA reviewing the remaining terms of the revised substitute claims would, in view of the specification of the '048 patent, understand the words used in those claims 29-44 to have their plain and ordinary meaning.

F. The Level of Ordinary Skill In The Art

29. As discussed above, I understand that claim construction, as well as written description, indefiniteness, and obviousness is viewed through the lens of a POSITA. In this matter the PTAB has found that a POSITA at the time of the invention would have had “a bachelor’s degree and two or more years of experience or a master’s degree in organic synthesis or chemical engineering, with education substituting for experience and vice versa.” **Paper 7** (Decision to Institute) at 6-7 (citing **Ex. 1002** at ¶ 16).

30. However, Dr. Taber also testified that a POSITA would likely have experience in industrial chemistry and would have worked at a chemical company, which I agree with. *See Ex. 2005*, p. 22, ll. 4-13. While Dr. Taber has extensive chemistry experience, he has never worked at a chemical company. It is also evident from his testimony that Dr. Taber does not have a background in heterogeneous catalysis and therefore his opinions in this matter are not credibly offered through the lens of a POSITA as they concern technology of heterogeneous catalysis relevant to the '048 patent.

31. Regardless of whether the PTAB finds that a POSITA would have industrial experience, the relatively low level of education and experience held by such a POSITA would not permit him or her to make inferences beyond the examples and most preferred embodiments disclosed in a particular prior art reference. For example, a POSITA would not be able to infer whether experimental results concerning a specific catalyst's conversion and regioselectivity could be analogized to other seemingly similar (or dissimilar) catalysts, or whether experimental results concerning a specific catalyst's conversion and regioselectivity for a particular substrate could be extended to other similar compounds. *See Ex. 1040*, p. 144, l. 11 – p. 146, l. 19. Such inferences could only be based on extensive experience such as that obtained through a doctoral program and several additional years of experience working in industry.

32. Despite his extensive experience in academic laboratories, statements in Dr. Taber's First, Second, and Third Declarations and testimony on cross examination raise significant questions concerning his understanding of the claimed process under which heterogeneous catalytic dehydration of 1-alkanols to 1-alkenes occurs. For example, Dr. Taber first referred to "calcined" as a "rather archaic term" that a POSITA "might operate without ever hearing the word" and could not predict what time and temperature would activate a catalyst; however, in his more recent statements "calcined" now seems to be a common process that is

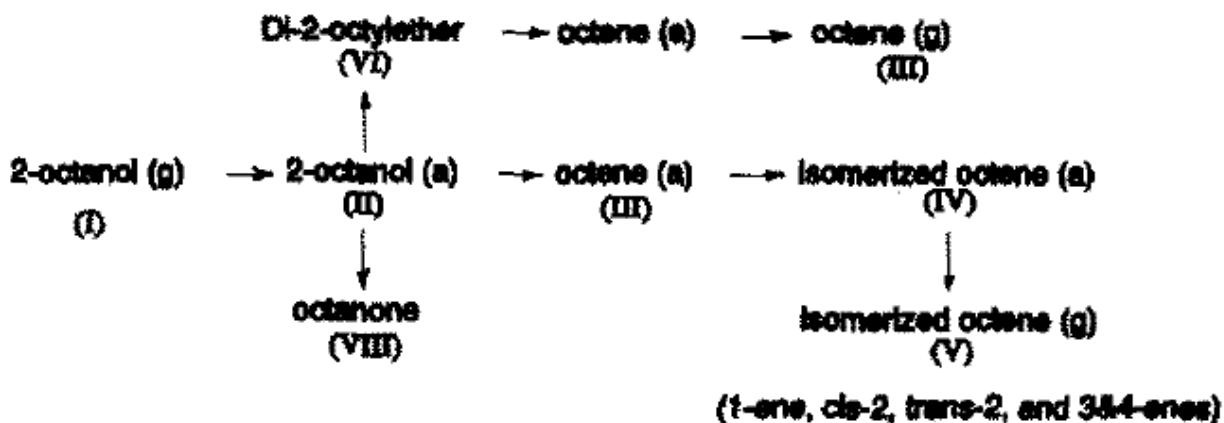
required for virtually all γ -alumina catalysts and is completely predictable.

Compare Ex. 2005, p. 69, l. 13 – p. 70, l. 3; p. 70, l. 16 – p. 71, l. 14 *with Ex. 2007*, p. 62, l. 14 – p. 65, l. 6; p. 83, l. 4 – p. 86, l. 6; p. 89, l. 13 – p. 91, l. 19; p. 97, l. 16 – p. 98, l. 6; p. 107, ll. 1-16; p. 115, l. 19 – p. 116, l. 9; p. 118, ll. 1-5, 14-17; p. 122, ll. 6-18. What is more, Dr. Taber's testimony has consistently been that a POSITA would first turn to a commercially available catalysts rather than embark on a time-consuming and expensive research program to identify a modified γ -alumina catalyst having superior regioselectivity, reactivity, and durability. *See Ex. 2005*, p. 91, ll. 2-8; p. 94, l. 2 – p. 95, l. 12; p. 100, l. 5 – p. 101, l. 9; p. 115, l. 20 – p. 116, l. 5; p. 116, ll. 6-14.

33. Further, in his discussion of the technology of the '048 patent, Dr. Taber cites to a sophomore level organic chemistry textbook, *Wade* (**Ex. 1030**) that discusses the acid-catalyzed solution phase dehydration of alcohols that proceed through a carbocation intermediate followed by deprotonation. **Ex. 1002**, ¶¶35-41 (citing **Ex. 1030**, pp. 313-14). A similar heterogeneous (solid-liquid phase) acid-catalyzed reaction is discussed in *Takamura* (**Ex. 1044**), which utilizes an acid-modified metal catalyst (preferably γ -aluminum) that is treated with an acid. *See Ex. 1044*, ¶¶[0037]-[0055]. Both *Wade* and *Takamura* discuss reactions that take place in the liquid phase, optionally with the use of solvents from which the reaction products are isolated after the reaction is complete. **Ex. 1044**, ¶[0074]-

[0075], [0080] (“the olefination reaction is preferably performed as a liquid phase reaction.”). Dr. Taber’s unwavering reliance on such irrelevant material only brings into great question his understanding the fundamentals of heterogeneous base-catalyzed alcohol dehydration (that a POSITA, even with the low-level of experience in this instance, would have).

34. However, as any POSITA would understand, the catalytic dehydration of 1-alkanols using the γ -alumina catalysts at issue in the '048 patent (and relevant prior art) occurs by flowing the 1-alkanol over the catalyst in the *gas phase*, and molecules react as they adsorb on active base sites of the catalysts. A good summary of the possible reactions that can occur during the catalytic dehydration of 2-octanol is provided in *Chokkaram*:



Scheme 1.

Ex. 1041, p. 164, col. 2 (Scheme 1). Despite having reviewed numerous prior art references such as *Chokkaram*, Dr. Taber’s Second and Third Declarations

nonetheless cite references such as *Takamura* (**Ex. 1044**), which discusses the catalytic dehydration of 1-alcohols in liquid solution over a solid catalyst. A POSITA would not find references such as *Takamura* (**Ex. 1044**) or *Wade* (**Ex. 1030**) relevant to the technology of the '048 patent. Dr. Taber nonetheless asserts that a POSITA would have been motivated to combine *De Bruyn* with *Takamura* to arrive at the presently claimed invention. *See, e.g., Ex. 1046*, ¶¶59-60, 73.

35. Furthermore, the calcining described in *Chokkaram* refers to chemical reaction of aluminum hydroxides (plus other metals) to form an “alumina” matrix and has nothing to do with calcining an already formed gamma-alumina. *See Ex. 1041*, pp. 158-164. A POSITA would be well aware that the change in surface area during catalyst formation (as in **Ex. 1041**) has no correlation to that of calcining an already formed γ -alumina catalyst that has been modified with a selected promoter.

36. Dr. Taber's lack of a basic understanding of how gas-phase catalysis is performed is further evident by his testimony that liquid reagents actually come into contact with the catalyst, and therefore lead to degradation. Specifically, Dr. Taber testified as follows:

Q. So just so we're clear, in all of these examples we're not adding liquid on to any of these reactors in Wu, in Wright '788, in Wright '451, or is it your testimony that literally wet liquid phase reagents are being added onto the catalyst?

A. Well, liquid phase starting materials are being added. At some point they vaporize at the temperatures of the reactor.

Q. So you're saying they're not preheated?

A. There may be a preheating in the reactor.

Q. Before the reagents get to the reactor your testimony is they enter the reactor as liquids and then hit the catalyst?

A. I don't see a reactor design outlined here. So I do not know.

Q. How about DeBruyn and Le, are they adding liquid reagents on to their reactors?

A. Nor do they have a reactor design. So I don't know.

Q. What is your understanding about how these processes are conducted under normal conditions in the art? Is it your testimony that under normal conditions liquid reagents are added directly into the reactor?

A. From an engineering point of view there would have to be containment of the substrate, of the starting material going in. And so in the world outside the reactor these starting materials are liquids. Somehow they get into the reactor, not necessarily the catalyst bed but into the reactor, they would have to go in as liquids. If you define the reactor as only being the catalyst bed, then presumably the liquids are not coming into contact with the catalyst bed. But if you define the reactor as being the whole reactor from where you put the substrate in, then yes, they go in as liquids.

Ex. 2007, p. 143, l. 21 – 145, l. 14. However, a POSITA working in this field

would know that liquid phase reactants never come into contact with the catalyst,

and that the reactants are always in the gas phase and adsorbed onto the catalyst.

The prior art need not spell out this basic concept in order for it to be understood,

but in case there is any doubt, it is stated in *Chokkaram* (**Ex. 1041**) as noted above,

and *Wright '451*, for example, explicitly states that “[a] preheater/vaporizer immediately upstream of the reactor was used to ensure that the nominally 100% 1-butanol feed (no diluent) was completely vaporized prior to delivery to the top of the upstream bed of glass beads.” **Ex. 1039**, ¶ [119].

37. A POSITA working in the field of alcohol dehydration would also know that alcohol dehydrations are endothermic and ether formation is exothermic. *See, e.g., Ex. 2009 (“Ward”)*. Specifically, *Ward* states: “[f]or ethanol, dehydration to ethene is favored at high temperatures (starting at 300 °C) as this is an endothermic reaction, whereas the exothermic formation of diethyl ether is favored at lower temperatures.” **Ex. 2009**, p. 2640.³ This is just one more example that Dr. Taber lacks the basic knowledge needed to evaluate what is normal, what is expected, and what is required to create a truly innovative and new heterogeneous catalyst/process, even at the level of a POSITA.

38. Dr. Taber also testified that he has no knowledge of “WHSV,” which is a basic concept in heterogeneous catalysis a POSITA would surely be aware of and is an acronym for “Weight Hour Space Velocity” and defines the weight of the

³ I am aware that *Ward* itself is not prior art to the '048 patent. However, it is reflective of the fact that a POSITA would have been well aware that dehydration is an endothermic process. Indeed, the references cited by *Ward* are from 2013 and 2015 (i.e., M. Zhang and Y. Yu, *Ind. Eng. Chem. Res.* 52:9505-9514 (2013) and T. K. Phung, L. Proietti Hernández, A. Lagazzo and G. Busca, *Appl. Catal., A* 493:77–89 (2015), respectively).

reactant feed flowing per unit weight of catalyst per hour. **Ex. 2005**, p. 64, ll. 10-19. Optimizing and controlling the WHSV is one of the two fundamental process control parameters any POSITA would understand before undertaking the dehydration of a bioalcohol using a heterogeneous catalyst. The other being temperature. Again, the POSITA in this matter has a B.S. in chemistry with at 1-2 years of industrial experience, or a masters degree with commensurate experience. In the general area of heterogeneous catalysis, any POSITA would understand WHSV and how to adjust it for achieving optimum catalyst performance.

39. Further, Dr. Taber testified that differences in temperature such as 290 °C vs. 315 °C “may not be very different” because the dehydration is exothermic and factors such as “the air conditioner kicks on in the other corner of the lab all of a sudden heat loss is greater” would lead to temperature deviations in the reactor of plus or minus twenty degrees. *See Ex. 2007*, p. 161, p. 1 – p. 163, l. 9. However, in my experience the flow rate of vapor-phase reagents into the reactor is always tightly controlled. Regardless of the endothermic or exothermic nature of the chemical reactions, heterogeneous reactors are fact designed (i.e. sufficient heating and/or cooling) to allow the operators to maintain a safe and accurate temperature control over the reactor and independent of room “air conditioners”. *See Ex. 2007*, p. 161, p. 1 – p. 163, l. 9. As mentioned above, alcohol dehydrations are mildly endothermic, so heating is the issue for reactor

designs. The energy required to vaporize and heat the bioalcohol is a much greater use of energy than the dehydration reaction itself (i.e. enthalpy). And, air conditioning “kicking on” in a room having any effect on a commercial chemical process reaction/reactor temperature is not a reasonable statement from a POSITA.

40. Dr. Taber also testified that a POSITA would “have experience in industrial chemistry or industrial processes” and “experience working at a chemical company” (**Ex. 2005** at p. 22, ll. 4-13), which he does not possess (**Ex. 2005**, p. 21, ll. 17-22) and is made very apparent by his written and oral testimony. And, while Dr. Taber testified that he has consulted with chemical companies, he did not testify that he discussed this matter or process chemistry and technology with those colleagues. Collectively in the two depositions and three declarations, it is evident that Dr. Taber lacks experience and the basic know-how of how to evaluate heterogeneous catalyst synthetic methods, catalyst performance, and ultimate value or utility in a commercial setting. Using such descriptions as “the POSITA would do as instructed” hardly suggests a working knowledge of heterogeneous catalysis, nor does assist a finder of fact in the current matter.

41. Despite these significant and large gaps in his knowledge of the heterogeneous catalysis processes at issue in this matter, Dr. Taber was keen to point to statements in prior art references that, in his opinion, would have led a POSITA to the inventions described in the '048 patent. For example, despite *Wu's*

silence on whether any of the catalysts used were calcined, Dr. Taber testified that a POSITA would understand that calcination always follows base treatment. **Ex. 2007**, p. 89, l. 13 - p. 91, l. 19; p. 118, ll. 1-17. Based on my experience, one cannot assume calcination has been carried out. As shown in *Wright '451* and the '048 patent, calcination, and how it was done, can have a significant impact and unexpected effect on catalyst performance, under both short- and long-term use (i.e., the latter referring to high time-on-stream). The bottom line is that a POSITA would not infer or assume that a calcination step has been done when none is reported.

42. Turning back to the mechanism of catalytic dehydration at issue in this case, Makgoba discusses the mechanism whereby “a proton is transferred from a surface hydroxyl group to the alcohol oxygen, facilitating the transfer of a proton on the neighboring carbon to a basic oxygen atom on the surface.” **Ex. 1027**, p. 145, col. 2. The olefinic product then desorbs “and the water molecule remains adsorbed on the surface and acts as a reaction inhibitor.” **Ex. 1027**, p. 145, col. 2 (citing *Catalytic Chemistry*, John Wiley and Sons Inc., New York, pp. 371-373 (1992)). Thus, the ability of a catalyst to maintain regioselective dehydrogenation of 1-alcohols to 1-alkenes at high and steady conversion rates and for extended duration of time-on-stream, was and is a crucial consideration for any commercial and sustainable bio-1-alcohol dehydration process. It is noteworthy that Petitioners

attempted (and apparently have failed) to develop their own catalytic dehydration process, which, far from achieving anywhere near the high-degree of both conversion and regioselectivity, instead relies on “moderate temperatures” and “recycling of side products and non-reacted educts.” *See Bugdahn (Ex. 2008)*, Abstract.

43. I note that Makgoba discloses processes whereby the conversion of 1-hexanol to 1-hexene is performed at 280 °C to 325 °C, while the conversion of 1-octanol to 1-octene is performed at 280 °C to 330 °C. **Ex. 1027** at 146, col. 2.

44. Typically, high regioselectivity for alcohol dehydration to 1-alkenes is obtained at lower temperatures with poor conversion. while higher temperatures provide higher conversion, however, afford lower regioselectivity. *See, e.g., Ex. 1041; see also Bugdahn (Ex. 2008)*. According to *Bugdahn* and co-workers at Petitioner, Symrise AG, “[u]sually, the selectivity of a reaction can be increased by using doped or modified catalysts. However, due to a decrease in reactivity generally higher reaction temperatures are required.” **Ex. 2008**, ¶[0056]. Of note, *Bugdahn* makes no mention of time on stream for any catalysts or that any catalysts were calcined.

45. Typically, base treatments of alumina, such as treatment with sodium, potassium, calcium and magnesium promoters, for example, increase regioselectivity but decrease activity for alcohol dehydration. As stated by *Le*, “a

basic catalyst, for example a barium-doped γ -alumina, is used to further increase the selectivity of the dehydration [and] ... an acidic catalyst is used to improve the reaction yield.” **Ex. 1007**, ¶ [0064]. Similarly, *Berteau* shows in Figure 4 that conversion of 1-butanol to butene increases with increasing temperature with untreated alumina. **Ex. 1043**, p. 130. Figure 6 of *Berteau* indicates that to achieve high conversion of 1-butanol to butene at lower temperatures, acid treatment is preferred over base treatment, such as treatment with sodium or magnesium promoters. **Ex. 1043**, p. 131. Indeed, *Berteau* states, “[c]ations, which present a negative specific effect on acidity, have to be eliminated for application in alcohol dehydration.” **Ex. 1043**, p. 135. Thus, prior to Inolex’s work described in the ’048 patent, there was a challenge in achieving high conversion of C₆ to C₁₀ 1-alcohols to the corresponding 1-alkenes while maintaining the high regioselectivity for the 1-alkene needed for a sustainable and viable chemical process using biofeedstocks.

46. The challenge of achieving high regioselectivity can be approached by running reactors under conditions that provide the desired regioselectivity, however, they provide lower alcohol conversion to alkene and other products (e.g. ethers). In theory, overall “net conversion” of alcohol for such a process can be improved by isolating the unreacted alcohol and ethers (i.e. a purification step(s)) and reintroducing (and heating) those materials back into the reactor (i.e., using a recycle stream). *See, e.g.*, **Ex. 1008**, ¶ [0053] (Example 3). However, this comes

with consequences, some quite severe: An increase of catalyst amount is needed, much higher energy inputs are required, strong potential of decreased catalyst lifetime (due to impurities in recycle stream), increased equipment cost and added failure points in the process, and an overall more complicated process to monitor and maintain a continuous 24/7 process. And even after recycling the unreacted starting materials (and by-products such as ethers), *De Bruyn* claims to achieve a 94% conversion of 1-hexanol to alkenes. **Ex. 1008**, ¶ [0053], although no experimental details to prove this claim nor discussion of how this was calculated or carried out are presented. Recycling is a very complicated process to carry out in a commercial setting, as any POSITA would know. In addition, in the current age of sustainable chemistry and processing technology, recycle streams are costly in critical areas such as economics, energy requirements, and waste emissions (such as CO₂ and used catalyst).

47. All of this is relevant to the analysis of the predictability in the art, and whether a POSITA would have any reasonable expectation of success in achieving the claimed invention based on the prior art disclosures. In other words, the level of predictability in the art can significantly impact an analysis of whether a particular claimed process is deemed non-obvious over the prior art. Here, the field of organic synthesis using heterogeneous catalysis has been an active area of research for more than 70 years. However, organic synthesis using heterogeneous

catalysis remains a highly unpredictable field with sometimes a slight change in processing of catalyst leading to a truly unexpected result. As I testified at my deposition, there is no way to predict how the treatment of a catalyst with, for example, a particular base, promoter, or other chemical will affect its performance for conversion and regioselectivity of a given substrate without conducting experiments. *See Ex. 1040*, p. 43, l. 18 – p. 45, l. 16; p. 139, ll. 1-20. I also made it very clear that 1-butanol does not behave as 1-octanol in heterogeneous catalytic dehydration, nor would a POSITA expect it to. *See Ex. 1040*, p. 81, l. 15 – p. 83, l. 10; p. 96, l. 17 – p. 99, l. 2; p. 100, l. 5 – p. 102, l. 3; p. 122, ll. 2-22; p. 124, l. 7 – p. 126, l. 17; p. 128, l. 13 – p. 130, l. 3; p. 133, l. 3 – p. 134, l. 9. What is more, Dr. Taber testified extensively that a POSITA in this field would need to conduct experiments in order to see “what worked.” *See Ex. 2005*, p. 30, l. 13 – p. 31, l. 10; p. 44, l. 7 – p. 45, l. 11; p. 54, l. 13 – p. 55, l. 7; p. 71, ll. 2-14; 92, l. 4 – p. 93, l. 15; p. 103, l. 10 – p. 104, l. 1.

48. What is more, a prior art disclosure, for example, that a calcination step was performed at a specific temperature for a specific time period with a first catalyst would not necessarily motivate a POSITA in this field to perform the same calcination on another catalyst, or to conclude that using the same calcination conditions would lead to a predictable result. This is plainly illustrated with Dr. Taber’s discussion of *Chokkaram* or *Takamura*, which, in my opinion, a POSITA

would not view as relevant to the dehydration process of the presently claimed invention. *See infra*; see also **Ex. 2006**, ¶¶8, 45-49.

IV. REVISED SUBSTITUTE CLAIMS 29-44 ARE PATENTABLY DISTINCT FROM CLAIMS 1-7, 9-11, 24-26, 28, 29, 35, AND 36 OF U.S. PATENT NO. 11,802,803

49. Independent substitute claim 29 requires the following:

29. A process for making a bio-alkene, comprising:

dehydrating a bio-1-alcohol by heating the bio-1-alcohol in a continuous flow reactor at a temperature of 240 °C to 360 °C with a calcium-promoted γ -alumina catalyst calcined at a temperature of about 420 °C to about 480 °C, wherein the catalyst has not been silanized, and

wherein the resulting bio-alkene has a carbon chain of 6 to 10 carbon atoms and is produced in a conversion of at least 95% and a bio-1-alkene regioselectivity of 95% to about 99% from a single-pass reaction after at least 20 hours time-on-stream.

(Patent Owner's Revised Non-Contingent Motion to Amend, Appendix A.)

Notably, substitute claim 29 is a method for making a bio-alkene that requires a specific γ -alumina catalyst, which is calcium-promoted then calcined at a temperature of about 420 °C to about 480 °C, but not silanized. The claimed catalyst dehydrates C₆ to C₁₀ bio-1-alcohols with both high bio-1-alkene regioselectivity of 95% to about 99%, and with a high conversion of at least 95% with a single pass, even after a time-on-stream of at least 20 hours.

50. I am named as an inventor on U.S. Patent No. 10,882,803 (“the ’803 patent”), but I was not involved in IPR2023-01439, which I understand was

prepared and submitted by the same Petitioners in this proceeding. I have been informed that after submitting my Second Declaration, Inolex disclaimed claims 1-7, 9-11, 24-26, 28, 29, 35, and 36 of the '803 patent. I have also been informed that claims 8-10, 12-23, 27, 30-34, 37, and 38 of the '803 patent were not challenged in IPR2023-01439 and were not disclaimed. Prior to preparing this Third Declaration, I had not analyzed any claims of the '803 patent. In order to ascertain whether there are any patentably distinct differences between the substitute claims 29-44 (at issue here) and disclaimed claims 1-7, 9-11, 24-26, 28, 29, 35, and 36 of the '803 patent, I prepared a chart summarizing these claims. *See Ex. 2011* (cols. 1 & 2). Also included in **Ex. 2011**, are claims 8-10, 12-23, 27, 30-34, 37, and 38 of the '803 patent, which I understand have not been disclaimed. I note that claims 8, 12, 13, 15, and 27 of the '803 patent are dependent claims that depend directly or indirectly from other claims of the '803 patent that were disclaimed. Referring to **Ex. 2011**, I have re-written claims 8, 12, 13, 15, and 27 of the '803 patent in independent form, incorporating by reference the limitations of disclaimed claims (which are in gray to indicate disclaimer). *See Ex. 2011*, col. 3. Also shown in column 3 are underlined limitations of claims 8-10, 12-23, 27, 30-34, 37, and 38 of the '803 patent of limitations that are present in substitute claims 29-44. *See Ex. 2011*.

51. At the outset, I note that both substitute claims 29-44 and claims 1-7, 9-11, 24-26, 28, 29, 35, and 36 of the '803 patent are directed to processes to prepare bio-1-alkenes, but the claims of the '803 patent includes an additional step of converting the bio-1-alkenes to bio-1,2-alkanediols. A POSITA would readily recognize that bio-1-alkenes have a wide range of commercial uses beyond the creation of bio-1,2-alkanediols, including for example, use in many polymerization reactions. *See, e.g., Ex. 1007 (Le)*.

52. Referring to **Ex. 2011**, I note that claims 1-7, 24-26, 28, 29, 35, and 36 of the '803 patent merely require a process that utilizes “a catalyst”—without any limitation as to what the catalyst is or how it is prepared. Further, claims 9-11 of the '803 patent merely require that “the catalyst is selected from ZnAl_2O_4 and γ -alumina catalyst.” I readily acknowledge that ZnAl_2O_4 and γ -alumina catalysts were known in the prior art, but strongly disagree that the catalysts required by substitute claims 29-44 are patentably indistinct from the generic categories of “ ZnAl_2O_4 and γ -alumina catalysts,” which cover thousands of different possible catalysts that can be, for example, doped or undoped, treated or untreated, calcined or not calcined. Dr. Taber takes an entirely unsupported and baseless view that selecting a catalyst is akin to choosing features on a new car, whereby a chemical treatment process or calcination temperature useful for one specific catalyst in the prior art is readily applicable to other, entirely different catalysts to yield

predictable results. *See, e.g., Ex. 1046*, ¶¶57, 59, 60 (alleging without any evidence that *Takamura*'s levels of acid oxides and temperatures for liquid phase reactions and calcination using the acid-doped catalysts would be applicable to calcium-promoted catalysts); ¶58 (discussing *Chokkaram*'s calcination temperature for entirely different catalytic oxides used to dehydrate 2-octanol would be applicable to the claimed catalysts). None of Dr. Taber's assertions hold water because he has not shown that any of the results would be predictable. The same is true of Dr. Taber's surface level analysis of substitute claims 29-44 over the disclaimed claims of the '803 patent.

53. Substitute claims 29-33, 36, 39, and 42 require "a calcium-promoted γ -alumina catalyst calcined at a temperature of about 420 °C to about 480 °C, wherein the catalyst has not been silanized." In my opinion, nothing in any of the disclaimed claims of the '803 patent teaches or suggests the catalyst required by the substitute claims, as there is no reference to a calcium-promoted γ -alumina catalyst, let alone a calcium-promoted γ -alumina catalyst that has been calcined at a temperature of about 420 °C to about 480 °C. What is more, substitute claims 34, 25, 37, 38, 40, 41, 43, and 44 require that "the calcium-promoted catalyst has been calcined at a temperature of about 440 °C to about 460 °C."

54. Attempting to fill in these gaps, Dr. Taber immediately turns to the specification of the '803 patent. *See Ex. 1046*, ¶21. However, as I understand it,

the obviousness analysis at issue in comparing the Disclaimed Claims to substitute claims 29-44 should be limited to the subject matter of the Disclaimed Claims themselves because the specification of the '803 patent cannot be used as though it were prior art, even where that disclosure is found in the claims. *General Foods v. Studiengesellschaft Kohle mbH*, 972 F.2d 1272, 1281 (Fed. Cir. 1992) (citing *In re Braat*, 937 F.2d 589, 594 n.5 (Fed. Cir. 1991)). The disclaimed claims of the '803 patent fail to specify, let alone make obvious, any of the process parameters required by the substitute claims—including the requirements of i) a calcium-promoted γ -alumina catalyst, ii) calcined at a temperature of about 420 °C to about 480 °C, iii) wherein the catalyst has not been silanized, iv) in a reactor at a temperature of 240 °C to 360 °C. Further, substitute claims 34, 25, 37, 38, 40, 41, 43, and 44 require that “the calcium-promoted catalyst has been calcined at a temperature of about 440 °C to about 460 °C.”

55. Not only are these process parameters required by the substitute claims not obvious in view of claims 1-7, 9-11, 24-26, 28, 29, 35, and 36 of the '803 patent, many of the process parameters required by the substitute claims are separately required by claims of the '803 patent that were not disclaimed by Inolex. Specifically:

- Claim 15 of the '803 patent requires “wherein the γ -alumina catalyst is treated with a calcium promoter to provide a modified γ -alumina catalyst”;

- Claim 16 of the '803 patent (which depends from claim 15) requires “wherein the modified γ -alumina catalyst is calcined to provide a calcined γ -alumina catalyst”;
- Claim 18 of the '803 patent (which indirectly depends from claim 16) requires “wherein the calcium promoter is used in an amount of about 1 weight percent to about 2 weight percent based on the weight of CaO determined after calcination”;
- Claim 20 of the '803 patent (which indirectly depends from claim 15) requires “wherein the temperature during calcination is about 420° C to about 480° C”; and
- Claim 21 of the '803 patent (which depends from claim 20) requires “wherein the temperature during calcination is about 440° C. to about 460° C.”

See Ex. 2011.

56. Further, none of claims 1-7, 9-11, 24-26, 28, 29, 35, and 36 of the '803 patent require a continuous flow reactor heated “at a temperature of 240 °C to 360 °C.” This limitation of substitute claim 29 is not recited by any claims of the '803 patent but instead only appears in the specification. Similarly, none of claims 1-7, 9-11, 24-26, 28, 29, 35, and 36 of the '803 patent require a continuous flow reactor “heated at a temperature of 315 °C to 350 °C.” This limitation of substitute

claims 35, 38, 41, and 44 is also not recited by any claims of the '803 patent and only appears in the specification.

57. Nor have I (or Inolex) admitted that any prior art discloses, let alone teaches or suggests, the claimed calcination temperatures or reactor temperatures used in combination with the catalyst required by substitute claims 29-44. **Ex. 1046**, ¶26. As discussed above, I acknowledge that prior art processes (such as *Chokkaram*) utilized similar calcination temperatures or reactor temperatures with other catalysts and other reagents. As I have attempted to explain at length in my three Declarations, the mere presence of a calcination or reactor temperature in the prior art would not provide a POSITA any motivation to utilize those same temperatures for the catalysts required by the substitute claims, let alone with any reasonable expectation of success.

58. Dr. Taber attempts to brush aside the fact that the substitute claims also require that the bio-1-alkene is “produced in a conversion of at least 95% and a bio-1-alkene regioselectivity of 95% to about 99% from a single-pass reaction after at least 20 hours time-on-stream” by arguing that disclaimed claims 6 and 7 at least require a single pass. **Ex. 1046**, ¶22. This completely ignores that a POSITA would have no understanding, let alone any reasonable expectation that disclaimed claims 6 and 7 could achieve the required regioselectivity or conversion in a single pass through the continuous flow reactor.

59. As I understand it, in analyzing whether the substitute claims are non-obvious variants over claims 1-7, 9-11, 24-26, 28, 29, 35, and 36 of the '803 patent, Dr. Taber should not be permitted to rely on subject matter that is not recited in those disclaimed claims, but instead is both disclosed in the specification of the '803 patent and separately required by claims of the '803 patent that Inolex has not disclaimed.

60. For all of the reasons discussed herein, I disagree with Dr. Taber's analysis concerning the obviousness of substitute claims 29-44 over claims 1-7, 9-11, 24-26, 28, 29, 35, and 36 of the '803 patent that were disclaimed by Inolex.

V. REVISED SUBSTITUTE CLAIMS 29-44 ARE DESCRIBED IN THE SPECIFICATION

61. Petitioners and Dr. Taber argue that previously presented substitute claims 29-44 fail the written description requirement based on the limitation "a conversion of at least 95% and a bio-1-alkene regioselectivity of 95% to about 99% from a single-pass reaction after at least 20 hours time-on-stream" because the substitute claims do not specify a flow rate, and the '048 patent purportedly fails to disclose a flow rate. **Ex. 1046**, ¶32. I disagree.

62. First, Dr. Taber does not disagree with my prior statement that a POSITA would know that temperature and flow rate (or, more precisely, WHSV) are two fundamental process parameters that can be controlled by an operator. **Ex. 1046**, ¶32 (citing **Ex. 2005**, ¶115). Therefore, for a specific catalyst at any specific

reaction temperature, a POSITA would understand that increasing reactor temperature and decreasing flow rate typically lead to increased 1-alcohol conversion but decreased regioselectivity (and *vice versa*). Therefore, a process that specifies the optimum temperature range that a specific catalyst dehydrates a specific 1-alcohol, provides sufficient information for a POSITA to be able to practice that process. Indeed, a POSITA would understand that the inventors were in possession of the claimed process—and could reproduce the claimed process—because it specifies that the catalyst is calcium-promoted and then calcined at a specific temperature, which is then heated in a reactor at a specific temperature. Nothing more is required because it is well within the capability of a POSITA to vary the flow rate.

63. Second, Dr. Taber ignores the fact that Example 5 of the '048 patent specifically discloses a flow rate of 0.2 mL/min. **Ex. 1001**, col. 27, ll. 20-28 and provides the catalyst weight used (Example 5). Thus, a POSITA reviewing Example 5 of the '048 patent would understand that the inventors were in possession of a method of using the claimed calcium-promoted catalyst at a flow rate of 0.2 mL/min. A POSITA would also recognize that similar flow rates could be utilized to practice the claimed processes. These conditions provide the POSITA with an exact WHSV for the invention's catalyst.

64. Third, Dr. Taber testified that process control variables such as flow rate would not have been important to a POSITA reviewing prior art dehydration processes described in references such as *Appleby* and *Komarewsky* (**Ex. 1028** and **Ex. 1029**, respectively). Rather, the most important information showing that those authors had developed a dehydration process was the results:

Q. Okay, so would a person of ordinary skill in the art expect there to be a difference between the 350 degree reaction temp described in Komarewsky and the 380 to 400 degree reaction temp described in Appleby?

A. There are many variables that are not mentioned in these articles, what was the mass of the aluminum oxide, the activated alumina that was used as a catalyst, what were the dimensions of this tubular heater. We do know that it was 40 centimeters long and 12 millimeters in diameter. Was that inside diameter or outside diameter? So it's a little difficult to compare the two precisely because we really don't know flow rates, all these things. We know they're both successful.

Ex. 2005, p. 36, ll. 8-22. Indeed, both *Appleby* and *Komarewsky* disclose how the catalysts were prepared and the temperatures at which the processes were performed. Therefore, I agree with Dr. Taber that a POSITA would both understand that *Appleby* (**Ex. 1028**), *Komarewsky* (**Ex. 1029**), and the '048 patent inventors were in possession of a dehydration process that provided the disclosed results, and a POSITA that wanted to reproduce the processes of *Appleby*, *Komarewsky*, or the '048 patent could do so based on those disclosures. Notably, the '048 patent gives exact part numbers for the reactor, temperature probe

location, flow rate, and catalyst weight, which would clearly demonstrate to a POSITA that the inventors were in possession of the claimed process—and, unlike so many of the prior art references that do not include such detailed information—enable the process to be reproduced.

65. Further, it is rather surprising that Dr. Taber is now alleging that flow rate would be essential information for a POSITA to know in order to practice the claimed invention, when he himself testified “I have no idea” what “WHSV” refers to, which is a basic concept in heterogeneous catalysis a POSITA would surely be aware of and is an acronym for “Weight Hour Space Velocity”. **Ex. 2005**, p. 64, ll. 10-19. WHSV is analogous to flow rate and defines the weight of the reactant feed flowing per unit weight of catalyst per hour, and optimizing and controlling the WHSV is one of only two fundamental process control parameters any POSITA would understand before undertaking the dehydration of a bio-1-alcohol using a heterogeneous catalyst, the other being temperature. Again, the POSITA in this matter has a B.S. in chemistry with at 1-2 years of industrial experience, or a masters degree with commensurate experience. In the general area of heterogeneous catalysis, any POSITA would understand WHSV and how to adjust it for achieving optimum catalyst performance.

66. In sum, a POSITA reading the specification of the '048 patent in its entirety would understand that the inventors were in possession of the claimed methods of making a bio-alkene.

VI. REVISED SUBSTITUTE CLAIMS 29-44 ARE NOT INDEFINITE

67. Petitioners and Dr. Taber argue that previously presented substitute claims 29-44 are invalid as indefinite because the phrase “heating the bio-1-alcohol in a continuous flow reactor at a temperature of 240 °C to 360 °C” can have two distinct and incompatible meanings. **Ex. 1046**, ¶36. I disagree.

68. First, as disclosed in the '048 patent as well as many other references of record, a POSITA would readily understand that continuous flow reactors can comprise one or more heated “zones,” the temperature of which can be independently controlled and monitored. *See Ex. 1001*, col. 15, ll. 34-39; **Ex. 1007**, ¶[0175] (discussing Fig. 1, which includes separate zones for reagent entry and the fluidized bed); **Ex. 2003**, p. 376, 379 (Fig. 1, describing a dual bed reactor that includes a pre-heater, and two separate thermocouple controls within the reactor); as well as Petitioners' own published patent application, **Ex. 2008**, at ¶[0126], which describes:

Heating was performed by an electrical heating mantle which has three temperature zones: a preheating zone ... ; a subsequent 50 cm long zone forming the catalytic fixed-bed and consisting of solid catalyst particles being arranged as a so-called fixed bed in the reactor thus forming the reaction zone or reaction chamber; followed

by a zone being 20 cm long filled with inert carborundum material (vertical arrangement from top to bottom). The three temperature zones are individually controlled.

69. A POSITA would also understand that a reactor having more than one heated zone is typically maintained at a constant temperature through the use of a feedback mechanism such as a thermocouple. In the case of a reactor having multiple heating zones, a POSITA would recognize that this permits the temperature of each zone of the reactor to be independently controlled and maintained at a constant temperature. Thus, a POSITA would understand that a “reaction tube” or “reactor” can either be “heated isothermally” (in which all the reactor zones are at the same temperature), or each of the reactor zones can be separately set to a temperature in the range of 240 °C to 360 °C. *See Ex. 1001*, col. 15, ll. 33-37.

70. A POSITA reviewing the specification of the '048 patent (as well as other references of record in this proceeding) would understand that a reactor (or separate zones of a reactor) are controlled at a specific temperature over the course of the process. *See Ex. 1001*, col. 26, ll. 52-67 (Example 3, in which the reactor temperature was maintained at 315 °C using a thermocouple); col. 27, ll. 20-35 (Example 5, in which the reactor temperature was maintained at 315 °C using a thermocouple); col. 29, ll. 1-11 (Example 11, in which the reactor temperature was maintained at 330 °C, 350 °C, or 370 °C). Indeed, a POSITA would readily

understand that “[i]t is also possible [and common] to carry out a series of experiments each at different temperatures” **Ex. 2002**, p. 108. Further, Dr. Taber himself testified a POSITA would understand that it is a goal to maintain a reactor at a constant temperature. *See* **Ex. 2007**, p. 161, ll. 4-14; p. 162, l. 22 – p. 163, l. 9. The temperature of a reactor (or separate zones of a reactor) is typically controlled through the use of a feedback mechanism such as a thermocouple. *See* **Ex. 1001**, col. 26, ll. 52-67 (Example 3); col. 27, ll. 20-35 (Example 5); **Ex. 2002**, p. 106 (“The reactor is generally placed in a suitable furnace and a thermocouple is inserted either in direct contact with the outside of the reactor next to the bed or in a sleeve inserted in the bed itself”); **Ex. 1041**, p. 159, col. 1. In the case of a reactor having multiple heating zones, a POSITA would recognize that this permits the temperature of each zone of the reactor to be independently controlled at a specific temperature. Thus, a POSITA would understand that a “reaction tube” can either be “heated isothermally” (in which all the reactor zones are at the same temperature), or each of the reactor zones can be separately maintained at a temperature in the range of 240 °C to 360 °C. *See* **Ex. 1001**, col. 15, ll. 33-37. There is simply no basis for Dr. Taber’s misinformed reading of the phrase at issue or the specification of the ’048 patent to suggest that a reactor or separate zones of a reactor would be heated dynamically as a function of time over the entire range of 240 °C to 360 °C.

71. Nor is there anything about the specific words of the phrase at issue that fails to inform a POSITA as to the scope of the claimed process. Indeed, based on my review of the prior art of record, similar language is commonly used to describe processes that can be carried out over a temperature range. *See, e.g., Ex. 1007*, ¶[0065] (describing a “reaction in which the alcohol formed is dehydrated can be carried out, for example, in the temperature range included from 250 to 400 °C”; *Ex. 1008*, ¶[0037] (describing “a dehydration reaction at temperatures from 200 to 450 °C...”); *Ex. 1027*, p. 146, col. 2 (which is Petitioners’ own published patent applications, and describes a reactor having multiple catalyst beds in one reactor, with reactions carried out at temperatures ranging from 280 to 325 °C). Indeed, Petitioners’ own published patent application describes dehydration reactions for 1-alcohols “wherein the dehydration and/or cleavage is performed at a temperature ranging from 255 °C to 290 °C” using a reactor having multiple zones that can be independently controlled and maintained at different temperatures. *See Ex. 2008*, ¶[0015], [0126].

72. Finally, I note that claims 35, 38, 41, and 44 use nearly identical words as the phrase in substitute claim 29 that is allegedly indefinite, but Dr. Taber did not identify any uncertainty or ambiguity as to the scope of those dependent claims. *See, Ex. 1046*, ¶[34-38].

73. In sum, there is no credible basis for Dr. Taber's allegation that a POSITA would believe that the specification of the '048 patent fails to inform him or her about the scope of the claimed process. Indeed, for the reasons discussed above there is no reasonable basis for a POSITA to conclude that the phrase at issue requires the temperature of a reactor to be varied over the entirety of the claimed range while practicing the process. Specifically, nothing in the specification of the '048 patent or the background of this technology (as reflected in the references of record) would indicate to a POSITA that the claimed process requires one to dynamically vary the reactor over the entire claimed temperature range while running the claimed process.

74. For these reasons, a POSITA reading substitute claim 29 (as well as substitute claims 35, 38, 41, and 44) in view of the specification and the background of the technology in the field would have a reasonable certainty as to the scope of the claimed invention.

75. Finally, based on the lack of ambiguity in the phrase at issue, in my opinion there is no reason to further construe the phrase "heating the bio-1-alcohol in a continuous flow reactor at a temperature of 240 °C to 360 °C," and it should have its plain and ordinary meaning that would be readily understood by a POSITA. In the event that the PTAB believes this phrase requires construction, a POSITA would understand that this phrase as it is used in substitute claim 29 (as

well as substitute claims 35, 38, 41, and 44) merely requires the continuous flow reactor to be “heated at a temperature within the specified range.”

VII. THE SCOPE AND CONTENT OF THE PRIOR ART

76. Petitioners and Dr. Taber have dropped several obviousness grounds, specifically, *Wright* '788 (Ex. 1012), as well as the combinations of *Le* (Ex. 1007) in view of *De Bruyn* (Ex. 1008), and *Wu* (Ex. 1025) in view of *Chokkaram* (Ex. 1041). The only obviousness grounds discussed in Petitioners' Opposition and Dr. Taber's Third Declaration are *Wright* '451 (Ex. 1039) (Ground 3), and *De Bruyn* (Ex. 1008) in view of *Takamura* (Ex. 1044) (Ground 4).

A. *De Bruyn* (Ex. 1008)

77. *De Bruyn* utilizes commercially available γ -alumina catalysts, but a POSITA would not know whether any of those catalysts had been chemically modified or calcined. Ex. 2001, ¶40, ¶55, ¶64; *see also* Ex. 2005 at p. 97, l. 21 – p. 99, l. 20; p. 101, ll. 6-20; Ex. 2007, p. 33, ll. 7-11; p. 125, l. 2 – p. 127, l. 20. However, Dr. Taber has stated—without any evidence—that a POSITA would know that the commercial catalyst Sasol uses is the product of treatment with calcium acetate followed by calcination. Ex. 2007, p. 32, ll. 14-19; p. 34, ll. 1-7. I disagree—not only is *De Bruyn* silent about whether the commercially available alumina catalysts used in *De Bruyn*'s examples were calcium-promoted or calcined, there is also no information about the temperature of calcination. In

contrast, the '048 patent discovered that the heating range for calcination after addition of promotor needs to be capped in order to achieve top catalyst performance. No POSITA nor even an expert in the field, such as myself, would have predicted that.

78. Further, a prior art reference that merely describes an optional chemical treatment of a catalyst as being *possible* would not teach or describe to a POSITA how to prepare a catalyst, let alone with any reasonable expectation about how it will perform and/or for how long. As is seen in prior art such as *Wu*, *Wright* '788, *Wright* '451, for example, the details of catalyst preparation matter—particularly for producing high conversion, high regioselectivity, and time-on-stream. And again noting, all examples for catalyst performance in *Wright* '451 were limited to 1-butanol. See **Ex. 1040**, p. 81, l. 15 – p. 83, l. 10; p. 96, l. 17 – p. 99, l. 2; p. 100, l. 5 – p. 102, l. 3; p. 122, ll. 2-22; p. 124, l. 7 – p. 126, l. 17; p. 128, l. 13 – p. 130, l. 3; p. 133, l. 3 – p. 134, l. 9.

79. Example 3 of *De Bruyn* discloses a catalytic process whereby 1-hexene is produced with a regioselectivity of greater than 92% and a conversion of at least 95%. See **Ex. 1038** at ¶ 47-48; **Paper 16** at 13. A POSITA reviewing *De Bruyn*'s Example 3, Example 4 (Step 5), and Example 5 (Step 4) in view of the data in **Ex. 1027** (p. 147, Fig. 2) would inform a POSITA that *De Bruyn* discloses a 1-alcohol conversion of about 75% with a 1-alkene regioselectivity of about 95%

resulting from a single pass of the relevant reactants over the catalyst. Indeed, Dr. Taber admits that *De Bruyn*'s Example 3 only obtains a conversion of 95% or greater by recycling the unreacted 1-alcohol and dihexyl ether (and impurities). **Ex. 1038** at ¶ 48 (citing **Ex. 1008** at [0053]); **Ex. 2007**, p. 127, l. 21 – p. 128, l. 13.

80. A POSITA reviewing *De Bruyn* would understand that promoted γ -alumina catalysts were known—for example, $\text{CaO} \cdot \text{Al}_2\text{O}_3$, $\text{Ca}_2\text{O}_3 \cdot \text{Al}_2\text{O}_3$ —but nothing in *De Bruyn* teaches or suggests which catalyst is preferred or calcination at the specific temperature range of about 420 °C to about 480 °C (**Ex. 1008**, ¶ [0037].) Thus, *De Bruyn* provides no teaching or suggestion as to which catalyst is preferred, and whether the preferred catalyst would be chemically modified or how and if it was calcined.

81. In sum, a POSITA would have understood *De Bruyn* as disclosing processes to dehydrate C_6 to C_8 1-alkanols using commercially available γ -alumina catalysts with a reasonable expectation when using a single pass through the reactor to obtain an alcohol conversion efficiency in the range of 59% to 77%, a 1-alkene regioselectivity in the range of 95% to 98%, and chemical yield of 1-alkene at 20% to 35%. (See, e.g., **Ex. 1008** at p. 11, Fig. 2 (describing percentage conversion, yield of octenes and purity versus TOS).) Importantly, the only discussion of catalyst activity as a function of TOS in *De Bruyn* shows a catalyst that performed poorly at even a modest amount of TOS. (See **Ex. 1008**, ¶ [0081],

Figure 2, Table 14.) Based on *De Bruyn*'s disclosure, Dr. Taber testified that a POSITA would first turn to a commercially available catalysts rather than embark on a time-consuming and expensive research program to identify a modified γ -alumina catalyst having superior regioselectivity, reactivity, and durability. *See Ex. 2005*, p. 91, ll. 2-8; p. 94, l. 2 – p. 95, l. 12; p. 100, l. 5 – p. 101, l. 9; p. 115, l. 20 – p. 116, l. 5; p. 116, ll. 6-14.

B. *Takamura* (Ex. 1044)

82. European Patent Pub. No. EP 2 990 395 ("*Takamura*," **Ex. 1044**) is titled "Method For Producing Olefin," and was published on March 2, 2016.

83. Takamura discloses that

The present invention relates to a method for producing an olefin, containing subjecting a raw material alcohol to dehydration reaction *in the presence of an acid catalyst*, in which the acid catalyst contains a metal oxide, the raw material alcohol contains two or more kinds of alcohols having different numbers of carbon atoms each being a primary aliphatic alcohol having 8 or more and 22 or less carbon atoms, and a temperature of the reaction is 200°C or more and 300°C or less.

Ex. 1044, ¶[0008].

84. The acid catalyst is prepared by reacting a metal oxide (preferably γ -alumina) with a weak acid such that an oxide of sulfur, tungsten, phosphorus, silicon, molybdenum, iron, cobalt, nickel, copper, zinc, boron, gallium, indium, germanium, tin, antimony, bismuth, or selenium (with sulfur, tungsten, phosphorus

and silicon being preferred, and sulfur being most preferred) is formed on the surface of the alumina. **Ex. 1044**, ¶¶[0045]-[0050]. Such oxides are prepared by preferably reacting sulfuric acid, ammonium sulfate, ammonium tungstate, diammonium hydrogen phosphate, or tetraethyl orthosilicate (with sulfuric acid being most preferred) with a metal oxide support, which results in a catalyst that “may rapidly progress the dehydration reaction of the alcohol and may provide the target olefin with a high yield.” **Ex. 1044**, ¶[0053].

85. The acidic γ -alumina catalysts of *Takamura* stand in stark contrast to the preferred low-acidity catalyst supports such as alumina, silica, titania, or zirconia utilized by *De Bruyn*. **Ex. 1008**, ¶[0037]. Therefore, a POSITA would see no logical relationship between the regioselective dehydration catalysts discussed in *De Bruyn*, and the acidic catalysts of *Takamura*. Not only is there no motivation to combine these references, Dr. Taber provides no specific details about how this would be done.

C. *Wright '451* (Ex. 1039)

86. Int'l Patent Pub. No. WO 2015/130451 (“*Wright '451*,” **Ex. 1039**) is titled “Regioselective Dehydration of Terminal Alcohols,” and was published on September 3, 2015. I am the same Michael E. Wright who is one of the named inventors of *Wright '451*.

87. *Wright '451* discloses the methods of preparing bio-1-alkenes from bio-1-alcohols, and in particular bio-1-butene from bio-1-butanol, by catalytic dehydration with a 1-alkene regioselectivity of greater than about 90%, about 90% to about 99%, or greater than about 95% using a γ -alumina catalyst that is 1) treated with a calcium promoter, 2) calcined, and 3) optionally reacted with an organosilane, washed, and dried. **Ex. 1039**, ¶[18], ¶[22].

88. *Wright '451* discloses the use of promoted γ -alumina catalysts that are prepared by modifying a γ -alumina catalyst with a Ca^{+2} compound. **Ex. 1039** at ¶[14]. “In some embodiments Ca^{+2} is the modifier and the Ca^{+2} compound is calcium acetate ($\text{Ca}(\text{OAc})_2$).” **Ex. 1039** at ¶[14]. According to *Wright '451*, “Calcium imparts an increase in reaction rate when compared to Group 1 metals such as sodium and potassium when used at similar wt% loading values. Furthermore, calcium provides an increase in selectivity for the terminal alkene product over use of Group 1 metals at high and comparable terminal olefin conversion.” **Ex. 1039** at ¶[14]. Having led this work, I can unequivocally state that, as reflected in the Examples of *Wright '451*, 1-butanol is the only alcohol that was dehydrated, and no attempts were made to dehydrate longer chain alcohols using the catalysts described in *Wright '451*.

89. *Wright '451* also discloses that:

Promoter (e.g. Group 2 metal) modified and heat-treated (e.g., calcined) catalysts can be further modified by

treatment with at least one organosilane to create new catalysts that are especially useful for the dehydration of 1-alcohols mixed with high wt% of steam. The promoter-organosilane-modified alumina catalysts afford high regioselectivity in forming 1-alkene and can perform for extended periods of time on stream with little loss in regioselectivity.

Ex. 1039 at ¶[15]. Thus, *Wright '451* teaches that silanized γ -alumina catalysts provided longer time-on-stream.

90. After modification with a Ca^{+2} compound, *Wright '451* discloses that the modified γ -alumina catalysts

[C]an be further heated ... to provide drying or calcination of the catalyst. The drying or calcination can be carried out in vessel **203** or **205** at temperatures of about 100 °C to about 900 °C, or about 200 °C to 600 °C for a time period of about 1 h to about 8 h, or about 2 h to 6 h.

Ex. 1039 at ¶[67]. Further, *Wright '451* discloses Examples 1-26 in which drying and/or calcination of various catalysts is performed at 120 °C, 200 °C, 500 °C, 550 °C, and/or 600 °C for various amounts of time. **Ex. 1039** at pp. 24-33 (Examples 2-4, 8-24).

91. *Wright '451* discloses that the dehydration methods are generally applicable to 1-alcohols of general formula $\text{R}^1\text{R}^2\text{CH}(\text{CH}_2)_2\text{OH}$, where R^1 and R^2 are independently H or a C_1 to C_{20} alkyl radical or contain one or more aromatic rings containing exclusively carbon or a mixture of carbon and heteroatoms, or a nitrile, alkene, or ketone functional group, or a combination thereof. **Ex. 1039** at

¶[21]. However, I note that all of the exemplary embodiments of *Wright '451* relate to catalytic dehydration of 1-butanol to form 1-butene. See **Ex. 1039** at 24-33.

92. *Wright '451* also discloses that the modified γ -alumina catalysts can be silanized (**Ex. 1039**, ¶[68]-¶[72]), and discloses examples in which the modified γ -alumina catalysts are both unsilanized or silanized. See **Ex. 1039** at 24-33 (Examples 4, 7, and 20-22 utilize silanized catalysts).

93. *Wright '451* also focuses on maintaining high conversion and high 1-butene selectivity for extended time-on-stream. In order to simulate extended periods of time-on-stream, *Wright '451* performed experiments in which the exemplary catalysts were: 1) tested immediately after preparation; 2) tested after heating for 60 hours at 400 °C under a continuous feed of 93 wt-% water and 7 wt-% 1-butanol; and 3) after a second 60 hours at 400 °C under a continuous feed of 93 wt-% water and 7 wt-% 1-butanol. Calcium-promoted γ -alumina catalysts calcined at 550 °C for 6 hours (i.e., Examples 18 and 19) maintained or even improved conversion efficiency after aging but exhibited decreased 1-butene regioselectivity. *Wright '451*, p. 31, Table 2. A calcium-promoted γ -alumina catalyst calcined at 500 °C and silanized (Examples 24 and 26) showed butanol conversion above 95% and 1-butene regioselectivity of 94% to 95% after almost 20 days of time-on-stream, again, for the conversion of 1-butanol.

94. In his Second Declaration, Dr. Taber repeatedly pointed to the presence of heptane in the dehydration of bio-1-butanol as a reason a POSITA would have relied on *Wright '451* because “the POSITA would know that adding the heptane to the 1-butanol would drive the water out of the 1-butanol.” **Ex. 2007**, p. 141, l. 19 – p. 143, l. 9; p. 145, l. 15 – 147, l. 10; p. 150, ll. 9-14. This rationale was notably dropped from Dr. Taber’s Third Declaration. Specifically, the addition of 2 wt-% heptane in *Wright '451* had no impact whatsoever on the miscibility of water in bio-1-butanol, as the heptane was completely miscible with the reactant solution of 88 wt% 1-butanol, 2 wt% heptane, and 10 wt% water. *See Ex. 1039*, ¶¶ [0042], [0043], [0045], [0046]. What is more, as noted above, during the dehydration reaction, the reactants are entirely in the vapor-phase as they pass into and through the reactor. A POSITA would understand that any γ -alumina catalyst, whether modified, base-treated, calcium-promoted, silanized, or treated in some other way, will cause no reaction of the heptane, and therefore heptane was present solely as an internal reference standard in order to better quantify the amount of 1-butene (and other by-products) formed by the dehydration reactions using gas chromatography (GC).

95. Example 8, also included in Fig. 9, shows that a calcium-promoted γ -alumina catalyst provides significantly better performance compared to a catalyst prepared with NaOH base. **Ex. 1039**, Fig. 9. Thus, a POSITA reading *Wright '451*

would understand that a higher conversion and regioselectivity could be obtained by treating a γ -alumina catalyst with a calcium promoter followed by calcination compared to treatment with an alkali metal hydroxide.

96. As stated previously, in my opinion a POSITA would view *Wright* '451 and *Wright* '788 as the closest prior art to the substitute claims. This is because *Wright* '451 and *Wright* '788 discloses catalysts that provide 1) high 1-alkene regioselectivity, 2) constant high alcohol conversion and yield, as well as selectivity for 1-alkenes, and 3) exceptional catalytic activity and regioselectivity after an extended period of time-on-stream. However, as *Wright* '788 is no longer being asserted as a ground for invalidity of the substitute claims, my discussion below focuses on *Wright* '451 and *De Bruyn* in view of *Takamura*.

97. I will also respond to Petitioners' baseless allegations that I have somehow withheld material information from the PTAB while participating in this proceeding. Paper 20, pp. 23-25. As discussed in the specification of the '048 patent, Inolex's processes were developed to convert bio-1-alcohols to bio-1-alkenes, and in particular bio-1-octanol to bio-1-octene. Prior to working with Inolex, I had extensive experience developing catalysts for the conversion of bio-1-butanol to bio-1-butene, but when I began working with Inolex's research team we quickly realized that prior art work with bio-1-butanol had very little applicability to bio-1-octanol and C₆ to C₁₀ 1-alcohols generally. See **Ex. 1040**, p. 125, l. 14 – p.

126, l. 3; 133, l. 3 – p. 134, l. 9. This is discussed in the '048 patent (Ex. 1001, col. 7, ll. 19-45), which reflects my prior work with the U.S. Navy and at Cobalt Technologies that silanized γ -alumina catalysts were “unequivocally” superior to base-treated catalysts that were not silanized. See **Ex. 1040**, p. 128, l. 13 – p. 130, l. 3. Petitioners now cite my testimony that “I knew this [*Wright '451*] was coming. It’s no surprise” as showing that I somehow withheld material information from the PTAB because I now state that *Wright '451* is the “closest prior art.” Paper 20, pp. 23-24. I stand by my testimony that a POSITA would view *Wright '451* and *Wright '788* as the closest prior art to the substitute claims because both teach the considerable benefit of using silanized γ -alumina catalysts to improve time-on-stream, which is reflected in the specification of the '048 patent. What is more, with respect to *Wright '451* specifically, I reiterate my oral and written testimony that *Wright '451* discloses general parameters and specific examples that work very well for 1-butanol, but just don’t work for 1-octanol. Specifically, at my deposition I stated that:

I have to admit I sort of looked at this [*Wright '451*]. I knew this was coming. It’s no surprise. This has been out in the literature. You can find it on Google. So I knew this would come up. Well, gee, this has already been invented. *Well, it really hasn’t because it gives you specifications which just don’t work. And you can’t operate in that range of 200 to 600 degrees, and the amount of loading of calcium is different, and so on, so on.*

I'd have to look back, but – we explored different calcium loadings, but I'm not sure, I have to be careful, I – I'd have to take the Inolex patent and look at this exactly and see if we loaded it exactly the same calcium loading, but I don't think so. I think Inolex was a bit higher.

Ex. 1040, p. 130, l. 16 – p. 131, l. 10.

98. It cannot be overstated that, because the work and examples in *Wright '451* and *Wright '788* utilize only 1-butanol and unequivocally demonstrate the superiority of silanized γ -alumina catalysts as improving TOS, I have always viewed these references as cumulative of one another. And, as the research in the '048 patent demonstrates, 1-butanol does not behave like 1-octanol in dehydration chemistry, and silanized γ -alumina catalysts do not provide the same high conversion and high regioselectivity for 1-octanol as is observed for 1-butanol. In my opinion, a POSITA would have found both of these results to be truly unexpected. **Ex. 1040**, p. 133, l. 21 – p. 134, l. 2.

VIII. REVISED SUBSTITUTE CLAIMS 29-44 ARE PATENTABLE OVER THE PRIOR ART

99. Independent substitute claim 29 requires the following:

29. A process for making a bio-alkene, comprising:

dehydrating a bio-1-alcohol by heating the bio-1-alcohol in a continuous flow reactor at a temperature of 240 °C to 360 °C with a calcium-promoted γ -alumina catalyst calcined at a temperature of about 420 °C to about 480 °C, wherein the catalyst has not been silanized, and

wherein the resulting bio-alkene has a carbon chain of 6

to 10 carbon atoms and is produced in a conversion of at least 95% and a bio-1-alkene regioselectivity of 95% to about 99% from a single-pass reaction after at least 20 hours time-on-stream.

(Patent Owner's Revised Non-Contingent Motion to Amend, Appendix A.)

Notably, substitute claim 29 is a method for making a bio-alkene that requires a specific γ -alumina catalyst, which is calcium-promoted then calcined at a temperature of about 420 °C to about 480 °C, but not silanized. The claimed catalyst dehydrates C₆ to C₁₀ bio-1-alcohols with both high bio-1-alkene regioselectivity of 95% to about 99%, and with a high conversion of at least 95% with a single pass, even after a time-on-stream of at least 20 hours.

A. Substitute Claim 29 is Patentable Over *De Bruyn* in View of *Takamura*

100. As discussed above, *De Bruyn* discloses the dehydration of 1-alcohols using commercially available γ -alumina catalysts. According to Dr. Taber, a POSITA would have no reason to review the literature or attempt to design new γ -alumina catalysts if catalysts such as those used in *De Bruyn* were available. **Ex. 2007**, p. 17, ll. 1-12. While a POSITA would know there are numerous sources of commercially available γ -alumina catalysts, Dr. Taber testified that he did not know what catalysts are available commercially. **Ex. 2007**, p. 17, l. 13-20. Dr. Taber nonetheless testified that a POSITA would simply use a commercially available γ -alumina catalyst—for example ESM 110[®] catalyst from Eurosupport or

the Pural[®] KR1 catalyst from Sasol. **Ex. 2001**, ¶ 56; **Ex. 2005** at p. 101, l. 21 – p. 103, l. 15; **Ex. 2007**, p. 17, ll. 1-12; p. 33, ll. 3-6; p. 126, l. 20 – p. 127, l. 10; p. 150, l. 15 – p. 151, l. 2. However, a POSITA would not know anything about how those commercially available catalysts were prepared—for example, whether commercial alumina catalysts had been chemically modified or calcined. *See* **Ex. 2001**, ¶ 40, ¶ 55, ¶ 64; **Ex. 2005** at p. 97, l. 21 – p. 99, l. 20; p. 101, ll. 6-20; **Ex. 2007**, p. 33, ll. 7-11; p. 125, l. 2 – p. 127, l. 20. And even if a POSITA were to infer that the commercial catalysts of *De Bruyn* had been calcium promoted (which *De Bruyn* merely teaches as being a possibility), a POSITA would expect that such calcium-promoted catalysts would be limited to conversion of 59% to 77% with a single-pass reaction.

101. Specifically, a POSITA would understand that *De Bruyn* discloses a γ -alumina catalyst to dehydrate 1-hexanol and 1-octanol with a 1-alkene regioselectivity of 96% to 98% and at a conversion efficiency of 59% to 77% after a single-pass reaction. *See* **Ex. 1008**, ¶ [0053], ¶ [0067]-¶ [0068], Table 10, ¶ [0080]-¶ [0083], Figure 2, Table 14. That is, *De Bruyn* compensates for the low conversion provided by the commercially available catalyst by isolating the 1-alcohol from the effluent stream and recycling it back into the reactor. *See* **Ex. 1008**, ¶ [0053] (Example 3); **Ex. 2007**, p. 127, l. 21 – p. 128, l. 9. Recycling unreacted starting materials is commonly done in large-scale dehydration of

alcohols, particularly on a large scale and/or where energy is inexpensive. **Ex. 2007**, p. 73, ll. 11-22; p. 127, l. 21 – p. 128, l. 9. Recycling reagents utilizes significantly more energy than a process capable of at least 95% conversion from a single-pass reaction. The fact that *De Bruyn* has a limited conversion efficiency of 59% to 77% after a single-pass reaction also speaks to the need in the art to develop processes and catalysts capable of much higher single-pass conversion, such as those described in the '048 patent.

102. A POSITA would have had no reason to combine *De Bruyn* with *Takamura*, because a POSITA would not view *Takamura* as relevant to the process described in *De Bruyn*. First, *De Bruyn* discloses a gas phase reaction that utilizes commercially available γ -alumina catalysts (e.g., EuroSupport ESM110[®], ¶¶ [0064] and [0171] and Pural[®] KR1, ¶[0066]). While Dr. Taber argues that *De Bruyn*'s mention of a calcium promoted γ -alumina catalyst (at **Ex. 1008**, ¶ [0037]) would have motivated a POSITA to modify a commercially available γ -alumina catalyst such as ESM110, it is entirely unclear how a POSITA would have done so in view of the teachings of *Takamura*. First, if Dr. Taber is correct that a POSITA would read *De Bruyn* as already providing a 1-alkene regioselectivity of greater than 95%, then a POSITA would have no reason whatsoever to further modify a commercially available γ -alumina catalyst. Second, Dr. Taber provides no scientific rationale how the preparation conditions utilized for an acid-modified

γ -alumina catalyst would be modified to inform the preparation of a calcium-promoted γ -alumina catalyst (which primarily contains basic surface sites). Indeed, Dr. Taber provides no discussion, let alone any scientific rationale as to why the concentration of acidic sites on a γ -alumina catalyst would be useful information to a POSITA in choosing to use a calcium-promoted γ -alumina catalyst (having basic sites and in which acidic sites are preferably not present), let alone what concentration of basic sites should be present on a calcium-promoted catalyst.

Third, Dr. Taber fails to explain why a POSITA would be motivated to use the calcination process of *Takamura* (which is specifically for an acid-modified γ -alumina catalyst) to calcine an entirely different chemical species (that is modified with a calcium promoter) with any reasonable expectation of success. Fourth, Dr. Taber fails to explain why a POSITA would selectively use the calcination conditions of *Takamura* (which are specific to acidic γ -alumina catalysts), but not modify the teachings of *De Bruyn* by also using the acidic chemical treatments that are taught by *Takamura*. Indeed, Dr. Taber's Third Declaration is wholly silent as to what, if any, similarities (or differences) between the preferred sulfur oxide (i.e., sulfate) dopants of *Takamura* and the claimed calcium oxide γ -alumina oxides would have motivated a POSITA to use the calcination conditions of *Takamura*, let alone with any reasonable expectation of success.

103. Nor is this a scenario in which it would be “obvious to try” modifying the commercially available γ -alumina catalyst of *De Bruyn* with the teaching of *Takamura* because the latter does not provide a finite number of identified, predictable solutions to the problems of catalyst modification, or methods of improving conversion while maintaining a high 1-alkene regioselectivity.

104. And to the extent that *Takamura* does so, a POSITA would have modified *De Bruyn* with the entire teaching of *Takamura*—including both acid modification and calcination. It is only through the use of impermissible hindsight that a POSITA would cherry pick the calcination conditions of *Takamura* without also applying *Takamura*’s teaching to use an acidic γ -alumina catalyst.

105. Dr. Taber argues that “Takamura explains to a POSITA that the aluminum oxide should support between 1-3% of the support element (e.g., the calcium of De Bruyn) to enhance the dehydration rate while suppressing side reactions.” **Ex. 1046**, ¶74 (citing **Ex. 1044**, ¶¶[0054]). I disagree. *Takamura* is entirely silent as to calcium oxide dopants, let alone their preferred concentration. A POSITA would therefore have no expectation that the level of acidic dopant in *Takamura* would have any relevance to the amount of calcium-promoted sites on a catalyst. Further, with respect to *Takamura*’s calcination temperatures as providing “enhancement of the dehydration reaction through the provision of a sufficient surface area maintenance of the degree of dispersion of the catalyst,” the disclosure

in *Takamura* that Dr. Taber points to concerns the preparation of the aluminum oxide support itself, prior to reaction with a dopant. See **Ex. 1046** (citing **Ex. 1044**, ¶[0057] (“The aluminum oxide as the support can be obtained, for example, by a precipitation method, a sol-gel method or an alkoxide method, and the aluminum oxide used is preferably calcined”)) and ¶[0063] (which only includes a discussion of calcination time, not temperature)). I note that *Takamura* at ¶[0062] discloses that the calcination temperature for the impregnated catalyst is “preferably 450 °C or more, from the standpoint of the enhancement of the dehydration reaction through the formation of the oxide of the element,” but, as noted above, Dr. Taber’s Third Declaration is wholly silent as to what, if any, similarities (or differences) between the preferred sulfur oxide (i.e., sulfate) dopants of *Takamura* and the claimed calcium oxide γ -alumina oxides would have motivated a POSITA to use the calcination conditions of *Takamura*, let alone with any reasonable expectation of success. What is more, as discussed above, to the extent a POSITA would view *Takamura* as relevant to any problem with calcination, the POSITA in this case having limited experience would focus on *Takamura*’s example, which teaches calcination of a γ -alumina catalyst that was treated with sulfuric acid and then calcined at 500 °C for 3 hours in air. **Ex. 1044**, ¶[0097]. Dr. Taber’s picking and choosing of selected teachings of *Takamura* smacks of hindsight, and is not what a POSITA would have done.

106. What is more, Dr. Taber provides no discussion as to why a POSITA reviewing *De Bruyn* in view of *Takamura* would be motivated to use a modified γ -alumina catalyst, such as a calcium-promoted catalyst. Indeed, the relevant experiments described by *De Bruyn* disclose a 1-alkene regioselectivity of 97.5% (Example 3), 96.5% (Example 4, Step 5), and 97% to 98% (Example 5, Step 4). See **Ex. 1008**, ¶ [0053], ¶¶ [0067]-[0068], Table 10; ¶¶ [0080]-[0083], Figure 2, Table 14. On cross examination, Dr. Taber testified that a POSITA would only look to other prior art or attempt to create a modified γ -alumina catalyst if he/she could not obtain a commercially available catalyst from a company such as SASOL. **Ex. 2007**, p. 16, l. 13 – p. 17, l. 12. As any POSITA working in the field of heterogeneous catalysis would know, there are numerous sources of commercially available catalysts—from SASOL as well as many other companies. If anything, the low conversions provided by *De Bruyn*'s examples would have motivated a POSITA to utilize an acidic catalyst “in order to improve the reaction yield.” **Ex. 1007**, ¶ [0064]. Notably, the catalysts disclosed by *Takamura* are acid-treated, but a POSITA would not be able to extend the teachings of *Takamura* concerning acid-treated catalysts to catalysts that are base-treated with any reasonable expectation of success because the chemistry of the catalysts is not amenable to combination (and Dr. Taber provides no scientific rationale for making such a combination).

107. Based on *De Bruyn*'s use of commercially available γ -alumina catalysts to obtain high regioselectivity, and *Takamura*'s teaching of solid acid catalysts to improve reaction rate, a POSITA reviewing *De Bruyn* and *Takamura* would not have been motivated combine *De Bruyn* with *Takamura* or to modify any of catalysts disclosed in these references with a base-treatment and/or a chemical promoter. *Takamura*'s teachings are directed to acidic metal oxides suitable for solution phase catalysis, and have nothing to do gas phase catalysis using calcium-promoted γ -alumina. Nor do *De Bruyn* or *Takamura* teach or suggest which chemical modifications and/or calcination conditions could be used to improve chemical conversion while maintaining high regioselectivity. Thus, *De Bruyn* and *Takamura* in view of any background knowledge in the art would not have motivated a POSITA to utilize a calcium-promoted and calcined (but not silanized) γ -alumina catalyst to dehydrate a C₆ to C₁₀ bio-1-alcohol. Indeed, *De Bruyn* and *Takamura* are wholly silent as to teaching the use of calcium-promoted γ -alumina catalysts or the effect that calcination of such a calcium-promoted catalyst has on conversion or 1-alkene regioselectivity. Thus, nothing in *De Bruyn* or *Takamura* would provide a POSITA any reasonable expectation that a calcium-promoted γ -alumina catalyst calcined at about 420 °C to about 480 °C could have any effect on the performance (positive or negative) of the dehydration of 1-alkanols, as measured by conversion, regioselectivity, or time-on-stream. Indeed, a

POSITA reviewing *Takamura* would understand that calcination could be performed, but would have no reasonable expectation that calcination of a calcium-promoted γ -alumina catalyst would have any predictable effect on the resulting conversion of 1-alcohols to 1-alkenes, 1-alkene regioselectivity, or time-on-stream. As such, the combination of *De Bruyn* and *Takamura* would not have motivated a POSITA to use the claimed catalyst to dehydrate a C₆ to C₁₀ bio-1-alcohol, wherein the resulting bio-alkene is produced in a conversion of at least 95% and a bio-1-alkene regioselectivity of 95% to about 99% from a single-pass reaction after at least 20 hours time-on-stream. Thus, *De Bruyn* in view of *Takamura* fail to provide a POSITA with any reasonable expectation that “a calcium-promoted γ -alumina catalyst calcined at a temperature of about 420 °C to about 480 °C, wherein the catalyst has not been silanized”.

108. It is only through hindsight that a POSITA reviewing *De Bruyn* would land on *Takamura* as a reference having any relevance to preparing base-treated or promoted alumina catalysts suitable for gas phase catalytic dehydration of bio-1-alkenes. That is, *Takamura*’s disclosure of acid-treatment of an alumina catalyst is entirely at odds with *De Bruyn*’s disclosure that low-acidic catalysts are preferred. Entirely ignoring this dichotomy, Dr. Taber nonetheless concludes that a POSITA would have relied on *Takamura*’s teachings concerning the preferred levels of acidic oxide sites on an alumina catalyst useful in a heterogeneous solid-liquid

phase reaction in order to modify a calcium promoted catalyst of *De Bruyn* for use in a solid-gas phase reaction.

109. In sum, a POSITA would not have combined *De Bruyn* with *Takamura*, and even if such a combination were made, *Takamura* does not remedy any of the deficiencies of *De Bruyn*. *Takamura* would not have informed a POSITA on the appropriate levels of calcium promoter to be used, or at what temperature a calcium-promoted γ -alumina catalyst should be calcined, let alone at a temperature of about 420 °C to about 480 °C. Thus, the combination of *De Bruyn* in view of *Takamura* provides no reasonable expectation that the claimed catalyst could be used with any reasonable expectation of success to provide the claimed result. For at least these reasons, and in view of any relevant secondary indicia of non-obviousness discuss *infra* in Sections VIII.B.2-4, in my opinion substitute claim 29 is patentable over *De Bruyn* in view of *Takamura*.

B. The Substitute Claims 29-44 Are Patentable Over *Wright* '451

110. *Wright* '451 was discussed at length in my Second Declaration, and here I attempt to address statements in Dr. Taber's Third Declaration concerning particular disclosures of *Wright* '451 that are wrong or inconsistent with how a POSITA would read *Wright* '451.

- 1. *Wright* '451 does not teach or suggest the calcination temperature range required by claim 29 to a POSITA with a reasonable expectation of success, and the claimed range provides unexpected results**

111. I disagree with Dr. Taber's conclusions that *Wright '451* teaches or suggests each and every limitation of substitute claim 29. **Ex. 1046**, ¶¶62-66.

Further, contrary to Dr. Taber's assertions, the claimed calcination temperature range of "about 420 °C to about 480 °C" for the specifically claimed "a calcium-promoted γ -alumina catalyst" provides unexpected results. **Ex. 1046**, ¶¶51-61.

112. *Wright '451* also discloses that calcium-promoted γ -alumina catalysts calcined at 500 °C, 550 °C, or 600 °C dehydrated 1-butanol to provide butene with an alcohol conversion of greater than 95% and a 1-butene regioselectivity of 95% to about 99%. *See Ex. 1039*, p. 31 (Table 2). I disagree with Dr. Taber's conclusion that a POSITA reviewing *Wright '451* would understand that these results were obtained for conversion of a C6 to C8 1-alcohol to 1-alkene. *See Ex. 1046*, ¶¶65-66.

113. *Wright '451* teaches that calcium-promoted γ -alumina catalysts:

[C]an be further heated ... to provide drying or calcination of the catalyst. The drying or calcination can be carried out in vessel **203** or **205** at temperatures of about 100 °C to about 900 °C, or about 200 °C to 600 °C for a time period of about 1 h to about 8 h, or about 2 h to 6 h.

Ex. 1039 at ¶[67]. *Wright '451*'s Examples 3, 8-22, 24, and 26 perform drying and/or calcination of various catalysts at 120 °C, 200 °C, 500 °C, 550 °C, and/or 600 °C for times of 30 min to 24 hours. **Ex. 1039** at pp. 24-33 (Examples 2-4, 8-22, and 24). The most frequently used calcination temperature in *Wright '451* is

550 °C (Examples 2-4 and 8-22), while a single example in *Wright '451* used a lower temperature of 500 °C (Example 24). I disagree with Dr. Taber's conclusion that a POSITA would view *Wright '451* as disclosing "a calcium-promoted γ -alumina catalyst calcined at a temperature of about 420 °C to about 480 °C" as required by substitute claim 29. **Ex. 1046**, ¶63. In particular, Dr. Taber has testified that running a reactor at a specific temperature is analogous to performing a calcination step at that same temperature. *See* **Ex. 1046**, ¶63; **Ex. 2007**, p. 90, l. 7 – p. 91, l. 4. However, Dr. Taber agreed that calcination is an entirely separate and different chemical process in which sites on and in a catalyst may react depending on the time, temperature, and atmosphere. **Ex. 2007**, p. 35, ll. 2-19; p. 36, ll. 10-14.

114. In my opinion, *Wright '451*'s disclosure of a calcination temperature range of about 200 °C to 600 °C for a time period of about 1 h to about 8 h, or about 2 h to 6 h (**Ex. 1039**, ¶[67]) with of drying and calcination at 120 °C, 200 °C, 500 °C, 550 °C, and/or 600 °C for times of 30 min to 24 hours (**Ex. 1039** at pp. 24-33 (Examples 2-4, 8-22, and 24)) does not disclose, let alone teach or suggest to a POSITA to specifically perform a calcination of any catalyst "at a temperature of about 420 °C to about 480 °C." A POSITA reading *Wright '451* would have no reason to lower the calcination temperature below 500 °C because the catalysts already provide high conversion, high regioselectivity and long TOS for 1-butanol. Nor does Dr. Taber assert as much. And to the extent he alleges such an

experiment would be obvious to try, there is no evidence that the results for a particular catalyst calcined at this temperature are predictable. **Ex. 2007**, p. 91, ll. 9-19.

115. In attempting to rebut Inolex's unexpected results associated decreasing the calcination temperature from 500 °C in *Wright '451*'s examples to "about 420 °C to about 480 °C," Dr. Taber first points to broad disclosures in the specification of *Wright '451*. **Ex. 1046**, ¶52. However, recognizing the gap in *Wright '451*, Dr. Taber then points to other prior art of record such as *Takamura* (**Ex. 1044**), *Chokkaram* (**Ex. 1041**), *Berteau* (**Ex. 1043**), and *Cortez* (**Ex. 1042**) that concern entirely different catalysts than those in *Wright '451* and purportedly would have provided "background" that would motivate a POSITA to modify the teachings of *Wright '451* to calcine a calcium-promoted γ -alumina catalyst at temperatures about 420 °C to about 480 °C and about 440 °C to about 460 °C. **Ex. 2010**, ¶¶55-60. I disagree with Dr. Taber's analysis.

116. As I have testified, the relatively low level of education and experience held by such a POSITA would not permit him or her to make inferences beyond the examples and most preferred embodiments of *Wright '451*. For example, a POSITA would not be able to infer whether experimental results concerning a specific catalyst's conversion and regioselectivity could be analogized to other seemingly similar (or dissimilar) catalysts, or whether

experimental results concerning a specific catalyst's conversion and regioselectivity for a particular substrate could be extended to other similar compounds. *See Ex. 1040*, p. 144, l. 11 – p. 146, l. 19. Such inferences could only be based on extensive experience such as that obtained through a doctoral program and several additional years of experience working in industry. Similarly, Dr. Taber testified a POSITA “might operate without ever hearing the word” calcined and could not predict what time and temperature would activate a catalyst. **Ex. 2005**, p. 69, l. 13 – p. 70, l. 3; p. 70, l. 16 – p. 71, l. 14. What is more, Dr. Taber's testified that a POSITA would first turn to commercially available catalysts rather than embark on a time-consuming and expensive research program to identify a modified γ -alumina catalyst having superior regioselectivity, reactivity, and durability. *See Ex. 2005*, p. 91, ll. 2-8; p. 94, l. 2 – p. 95, l. 12; p. 100, l. 5 – p. 101, l. 9; p. 115, l. 20 – p. 116, l. 5; p. 116, ll. 6-14. In sum, Dr. Taber provides unsupported and conclusory testimony based on hindsight to cherry pick prior art disclosures of calcination temperatures for entirely different catalysts, and then alleges that a POSITA having very limited experience in this area would apply those same calcination temperatures to the claimed “calcium-promoted γ -alumina catalyst” that has not been silanized—and doing so would obtain expected, predictable results. In my opinion, Dr. Taber's opinions at ¶¶52 and 55-60 fail to

analyze the issue through the lens of a POSITA, and therefore should be rejected as unreliable.

117. Dr. Taber also takes issue with the data presented at Table 5 of the '048 patent because it is allegedly not an apt comparison and “is a single data point.” **Ex. 1046**, ¶¶53-54. I disagree. Based on Wright '451's teaching to utilize a calcination temperature of 500 °C, it was entirely appropriate for Inolex to conduct its own experiments at that same temperature for comparison. This is simply utilizing the scientific method. Indeed, had Inolex not performed an experiment to reproduce the calcination temperature of 500 °C, it would have had no way to make an apples-to-apples comparison with the teachings of *Wright '451*.

118. Turning back to the experiments at issue, the '048 patent discloses that 1-octanol was dehydrated with γ -alumina catalyst that was first treated with a calcium acetate (i.e., promoter) solution, followed by calcination in air at 440 °C or 500 °C for 12 hours. Dehydration conducted at 315 °C provided conversion (to octenes) of 97.2% and 95.5%, respectively, with a regioselectivity of 97.4%⁴ and 93.1% (per Table 2). **Ex. 1001**, col. 26, l. 10 – col. 27, l. 9 (Examples 1-3). Thus, the '048 patent demonstrates that the higher calcination temperature of 500 °C (as taught by *Wright '451*) resulted in a less selective catalyst. That is, a calcium-

⁴ I note that the calculation of 1-Octene Selectivity for Example 1 in Table 2 appears to be incorrect and should be 96.7%.

promoted catalyst calcined at the lower temperature of 440 °C exhibited markedly better regioselectivity for 1-octene and also exhibited higher conversion compared to the same catalyst calcined at 500 °C. Nothing in *Wright* '451 (or any of the other prior art cited by Dr. Taber) could have predicted this result.

119. Further, a POSITA would view the results provided by the lower calcination temperature of 440 °C as a difference in kind and not one of degree. Indeed, in this field obtaining even a 1-2% improvement in either conversion or 1-alkene regioselectivity can provide significant benefit from the perspective of reactor design and operating costs—for example, by eliminating a recycling stream. Here, 1-octene regioselectivity increased from 93.1% to 96.7% and conversion increased from 95.5% to 97.2%. A POSITA would view these improvements as significant for either variable, but to see improvements in both is very significant and highly unexpected

120. Lastly, Dr. Taber purports to take issue with these results because they do not show that there is a negative impact from calcination at 500 °C. Ex. 1046, ¶54. But that is not required. Rather, the data show something unexpected compared to the higher calcination temperatures that are used in *Wright* '451 and many other prior art references. Nor is there any need for a POSITA to be able to make a “blanket determination” based on this result, as Dr. Taber would have it. Ex. 1046, ¶54. Rather, this result is limited to the claimed “calcium-promoted γ -

alumina catalyst” that has not been silanized. Finally, Dr. Taber cites no support for his “additional sources of data” that contradict the experiments of the ’048 patent and this statement can be ignored.

121. In sum, I disagree with Dr. Taber’s attempted rebuttal for the reasons above. Based on *Wright* ’451’s disclosure of preferred calcination temperatures of 200 °C to 600 °C, and examples at 500 °C and 550 °C, in my opinion a POSITA would view this result as entirely unexpected.

2. The substitute claims provide unexpected results over the prior art silanized γ -alumina catalysts

122. As set forth in my Second Declaration, the ’048 patent also discloses unexpected results over a prior art γ -alumina catalyst that was first treated with a base, dried, silanized, and then calcined at 400 °C. *See* **Ex. 1001** at p. 23, col. 28, ll. 51-67; **Ex. 1006** at pp. 61-62 of 719; **Ex. 1005** at pp. 42-43 of 236. As I testified at length in my deposition (and as disclosed in the ’048 patent), the closest prior art to the catalyst developed by Inolex were the silanized catalysts developed from my research at the U.S. Navy and Cobalt Technologies.

3. The reactor temperature ranges of the substitute claims provide unexpected results

123. *Wright* ’451 teaches that “the lowest 1-butanol conversion is always at 340 °C and *conversion increases with temperature.*” **Ex. 1039**, ¶¶ [13], [42].

124. As discussed in the '048 patent, dehydration reactions conducted at 330 °C and 350 °C provided conversion (to 1-, 2-, and 3-hexenes) of 96.3% and 96.9%, respectively, with a regioselectivity for the formation of 1-hexene of 95.8%⁵ and 96.8% (as reported in Table 5, below).

TABLE 5

Catalyst	Reactor Temperature (° C.)	1-Hexene (%)	2-Hexenes & 3-Hexene (%)	1-Hexanol (%)	1-Hexene Selectivity (%)
EXAMPLE 11A	330	92.8	3.5	1.8	95.8
EXAMPLE 11B	350	93.8	3.1	1.7	96.8
EXAMPLE 11C	370	90.1	3.2	1.6	96.6

Ex. 1001, col. 29, ll. 1-25 (Example 11). Surprisingly, increasing the reactor temperature to 370 °C reduced conversion (to hexenes) to 93.3% (from 96.9% at 350 °C), while maintaining a regioselectivity of 96.6% (as shown in Table 5, above). This temperature sensitivity was unexpected, particularly in view of prior art calcium-promoted catalysts such as those disclosed in *Wright '451* that provide conversion in excess of 95% at 380 °C. See **Ex. 1039**, Figs. 10-12.

125. Dr. Taber posits that the reduced conversion with increasing temperature may be due to the formation of ether dimer, which can then form 1-hexene. Ex. 1046, ¶47. However, regardless of the mechanism at work (which would be well beyond the ability of a POSITA to investigate), the data nonetheless

⁵ I note that the calculation of 1-Hexene Selectivity for Example 11A in Table 5 appears to be incorrect and should be 96.4%.

show that the claimed catalyst provided reduced conversion at higher temperature with constant regioselectivity. Further, while Dr. Taber asserts that experiment and data is not an apt comparison with *Wright '451*, he nonetheless does not dispute *Wright '451*'s statement that “*conversion increases with temperature.*” **Ex. 1039**, ¶¶ [13], [42]; **Ex. 1046**, ¶¶45-50. And to the extent these observations are “consistent with prior art teachings and are not unexpected,” Dr. Taber cites no such prior art teachings. **Ex. 1046**, ¶50.

126. As discussed in my Second Declaration, a POSITA would also view this result as unexpected based on *Wright '451*'s teaching that the lowest 1-butanol conversion is always at 340 °C and *conversion increases with temperature.*” **Ex. 1039**, ¶¶ [13], [42]. Nothing in *Wright '451* would have taught or suggested to a POSITA that conversion of 1-hexanol would decrease at 370 °C. A POSITA would view increase in conversion at lower temperatures as a difference in kind and not one of degree. As discussed above, even a 1-2% improvement in conversion can provide significant design and operational benefits. Here, 1-hexene conversion increased from 93.3% to 96.9% while maintaining regioselectivity. A POSITA would view this improvement as significant.

127. In sum, the results in Examples 3 and 11 showing the surprising effect of the claimed calcination temperature and reactor temperature using the specific catalyst, which is reflected in substitute claim 29 requiring dehydrating a bio-1-

alcohol by heating the bio-1-alcohol in a continuous flow reactor at a temperature of 240 °C to 360 °C, and substitute claims 35, 38, 41, and 44 requiring “the reactor is heated at a temperature of 315 °C to 350 °C.”

4. The substitute claims satisfy a long-felt need and show success where others have failed

128. There can be no dispute that the dehydration of 1-alcohols has been an area of active research for more than 70 years, and in the current age of sustainable chemistry and processing technology there has always been a need for improved methods that reduce energy requirements and waste emissions (such as CO₂ and used catalyst). To my knowledge, Inolex is the first company to have developed a specific catalyst and process suitable for dehydrating C₆ to C₁₀ bio-1-alcohols with a conversion of at least 95% and a bio-1-alkene regioselectivity of 95% to about 99% from a single-pass reaction after at least 20 hours time-on-stream.

129. Others in the past have achieved higher overall “net conversion” of alcohol by isolating the unreacted alcohol and ethers (i.e. a purification step(s)) and reintroducing (and heating) those materials back into the reactor (i.e., using a recycle stream). *See, e.g., Ex. 1008*, ¶ [0053] (Example 3). However, this comes with consequences, some quite severe: An increase of catalyst amount is needed, much higher energy inputs are required, strong potential of decreased catalyst lifetime (due to impurities in recycle stream), increased equipment cost and added failure points in the process, and an overall more complicated process to monitor

and maintain a continuous 24/7 process. And even after recycling the unreacted starting materials (and by-products such as ethers), *De Bruyn* claims to achieve a 94% conversion of 1-hexanol to alkenes. **Ex. 1008**, ¶ [0053],

130. Thus, the ability of a catalyst to maintain regioselective dehydrogenation of 1-alcohols to 1-alkenes at high and steady conversion rates and for extended duration of time-on-stream, was and is a crucial consideration for any commercial and sustainable bio-1-alcohol dehydration process.

131. While my prior work, as described for example, in *Wright '788* and *Wright '451* provided processes for the conversion of 1-butanol to 1-butene, it cannot be overstated that 1-butanol does not behave as 1-octanol in heterogeneous catalytic dehydration, nor would a POSITA expect it to. *See Ex. 1040*, p. 81, l. 15 – p. 83, l. 10; p. 96, l. 17 – p. 99, l. 2; p. 100, l. 5 – p. 102, l. 3; p. 122, ll. 2-22; p. 124, l. 7 – p. 126, l. 17; p. 128, l. 13 – p. 130, l. 3; p. 133, l. 3 – p. 134, l. 9. Therefore, in my opinion the substitute claim satisfy a long-felt need.

132. Further, many other researchers are still very active in this field and are still attempting to develop processes that are competitive with Inolex's. It is noteworthy that Petitioners attempted (and apparently have failed) to develop their own catalytic dehydration process, which, far from achieving anywhere near the high-degree of both conversion and regioselectivity, instead relies on “moderate

temperatures” and “recycling of side products and non-reacted educts.” *See Bugdahn (Ex. 2008)*, Abstract.

C. Substitute claims 34, 37, 40, and 43 are additionally patentable over the prior art of record

133. Substitute claims 34, 37, 40, and 43 depend from claims 33, 36, 39, and 42, respectively, which require that “the calcium-promoted γ -alumina has a CaO content of about 1% to about 2%” and more narrowly reflect the examples of the ’048 patent. Substitute claims 34, 37, 40, and 43 further require that “prior to the dehydrating, the catalyst has been calcined at a temperature of about 440 °C to about 460 °C.” (Patent Owner’s, Revised Non-Contingent Motion to Amend at Appendix A.) As discussed above, the disclosures of *De Bruyn* in view of *Takamura*, would not have motivated a POSITA to use a calcium-promoted γ -alumina catalyst that is then calcined at a temperature of about 420 °C to about 480 °C. Nor does *Wright ’451* disclose or suggest the use of a calcium-promoted γ -alumina catalyst that is then calcined at a temperature of about 440 °C to about 460 °C. Rather, *Wright ’451* discloses calcination of a calcium-promoted γ -alumina catalyst at a preferred temperature range of 200 °C to 600 °C, with specific calcination conditions disclosed at 500 °C, 550 °C, and 600 °C. Thus, the closest prior art to the revised substitute claims is *Wright ’451*’s disclosure of calcination of a calcium-promoted γ -alumina catalyst at 500 °C.

134. As set forth in the '048 patent specification, a calcium-promoted γ -alumina catalyst that is calcined at a temperature of about 440 °C to about 460 °C, provides a bio-1-alkene regioselectivity of 97%, alcohol conversion of 97%, and a chemical yield of 94%; whereas, calcination at a temperature of 500 °C reduced bio-1-alkene regioselectivity to 93%, alcohol conversion to 95.5%, and the chemical yield of 1-octene drops to 88%. (See **Ex. 1006** at p. 43 of 719, ¶ [0076], Table 1; **Ex. 1005** at p. 24 of 236, ¶ [0076], Table 1.) In my opinion, a POSITA would find the fact that a lower calcining ceiling temperature afforded an optimum catalyst in terms of both regioselectivity and conversion to be a truly unexpected result. And nothing in *De Bruyn* in view of *Takamura* or *Wright '451* teaches or suggests that base treatment and calcination at a temperature of about 440 °C to about 460 °C can improve 1-alkene regioselectivity, alcohol conversion, and chemical yield of the target 1-alkene (particularly at reactor at a temperature of 240 °C to 360 °C). For this additional reason, claims 34, 37, 40, and 43 are non-obvious over the prior art of record in this proceeding, including *De Bruyn* in view of *Takamura*, or *Wright '451*.

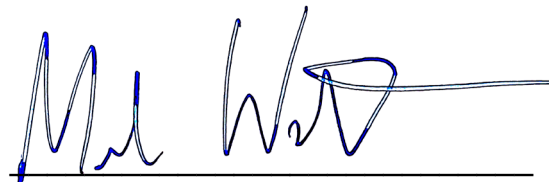
IX. CONCLUSION

135. In view of the foregoing, I conclude that substitute claims 29-44 of the '048 patent would not have been obvious to a POSITA in view of the prior art and arguments cited in Petitioners' Opposition to Patent Owner's Revised Motion to

Amend. In particular, I understand that in a field with extensive prior art disclosures, such as this one, secondary indicia of non-obviousness such as unexpected results, long-felt need, and the failure of others are particularly strong and reliable indicators of non-obviousness. Based on my extensive experience field in this area, it is my strong conviction that a POSITA viewing the prior art as a whole against the disclosure of the d'048 patent and the unexpected results, long-felt need, and failure of others to develop a similar process would come to the conclusion that substitute claims 29-44 are not obvious. Accordingly, for the reasons discussed herein it is my opinion that revised substitute claims 29-44 of the '048 patent are patentable over the prior art of record.

I declare under penalty of perjury that, to the extent of my knowledge and belief, the foregoing is true and correct. I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the understanding that knowing and willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of title 18 of the United States Code.

Dated August 15, 2024

A handwritten signature in blue ink, appearing to read "Michael E. Wright", written over a horizontal line.

Michael E. Wright, Ph.D.