

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SYMRISE AG

PETITIONER,

v.

INOLEX INVESTMENT CORPORATION,

PATENT OWNER.

IPR2023-01035
Patent 10,995,048

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 10,995,048**

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LIST OF EXHIBITS

Exhibit No.	Description
Exhibit 1001	U.S. Patent No. 10,995,048 (“the ’048 Patent”)
Exhibit 1002	Declaration of Dr. Douglass F. Taber
Exhibit 1003	U.S. Provisional Patent Application No. 62/623,985
Exhibit 1004	File History of U.S. Patent No. 10,882,803
Exhibit 1005	File History of U.S. Patent No. 10,995,048
Exhibit 1006	File History of U.S. Patent No. 11,414,365
Exhibit 1007	U.S. Patent Publication No. 2011/0196114A1 (“Le”)
Exhibit 1008	U.S. Patent Publication. No. 2005/0065389A1 (“De Bruyn”)
Exhibit 1009	U.S. Patent Publication. No. 2012/0238788 (“Wright ’788”)
Exhibit 1010	U.S. Patent No. 6,528,665 (“Cheng”)
Exhibit 1011	PCT Written Opinion of the International Searching Authority, PCT/US2015/014943. Issued April 29, 2015
Exhibit 1012	U.S. Patent No. 8,912,373 (“Wright ’373”)
Exhibit 1013	U.S. Patent No. 8,173,850 (“Furuya”)
Exhibit 1014- Exhibit 1019	<i>Reserved</i>
Exhibit 1020	U.S. Patent No. 10,894,750 (“Vecchini”)

Exhibit 1021	U.S. Patent No. 9,908,837 (“Colby”)
Exhibit 1022	U.S. Patent No. 8,765,430 (“Parekh”)
Exhibit 1023	U.S. Patent No. 8,597,922 (“Alibhai”)
Exhibit 1024	U.S. Patent No. 7,795,484 (“Koivusalmi”)
Exhibit 1025	U.S. Patent No. 4,234,752 (“Wu”)
Exhibit 1026	German Patent DE3915493 (“Voeste”) (translation)
Exhibit 1027	N.P Makgoba et al “ <i>Silication of -γ-alumina catalyst during the dehydration of linear primary alcohols,</i> ” Applied Catalysis A: General 297 (2006) 145-150 (“Makgoba”)
Exhibit 1028	W.G. Appleby <i>et al.</i> “ <i>Vapor Phase Dehydration of 1-Heptanol over Activated Alumina,</i> ” J. AM. CHEM. SOC. 66: 1938-1939, 1944 (“Appleby”)
Exhibit 1029	V. I. Komarewsky <i>et al.</i> “ <i>Catalytic Dehydration of 1-Hexanol and 1-Octanol,</i> ” J. AM. CHEM. SOC. 67: 557-558, 1945 (“Komarewsky”)
Exhibit 1030	L. G. Wade, Jr. Organic Chemistry, Chapters 7 and 8 (8th Ed. 2013) (“Wade”)
Exhibit 1031	JAOCS Vol. 62, No. 2, 355-365 (1985) (“Reck”)
Exhibit 1032	JAOCS Vol. 61, No. 2, 343-347 (1984) (“Kreutzer”)
Exhibit 1033	W. E. Schiegl and J. C. Vogel “ <i>Deuterium Content of Organic Matter,</i> ” EARTH AND PLANETARY SCIENCE LETTERS 7:303-313, 1970 (“Schiegl”)
Exhibit 1034	Harmon Craig, “ <i>Standard for Reporting Concentrations of Deuterium and Oxygen-18 in Natural Waters,</i> ” SCIENCE 133: 1833-1834, 1961 (“Craig”)

Exhibit 1035	WO 2001/044145 (“Tiitta”)
Exhibit 1036	U.S. Patent No. 9,029,619 (“Vermeiren”)
Exhibit 1037	WIPO Publication WO 2004/078336 (“Ziehe”)

I. Introduction

Symrise AG and Symrise Inc., (collectively “Petitioner”), hereby respectfully requests *Inter Partes* Review pursuant to 35 U.S.C. § §311 *et seq.* and 37 C.F.R. § §42.100 *et seq.*, of claims 1-6, 8-10 and 22-28 of U.S. Patent No. 10,995,048 (“the ’048 Patent”) filed on November 13, 2019, and issued on May 4, 2021, to Inolex Investment Corporation (hereinafter “Patent Owner”).

The ’048 Patent claims a very well-known chemical process for producing highly regioselective 1-alkenes by dehydrating 1-alcohols with a catalyst. The ’048 Patent’s allegedly distinguishing characteristic is that its process uses non-petroleum or “bio” starting materials. Yet, the ’048 Patent fails to explain why this well-known process of dehydrating 1-alcohols would operate differently using “bio” feedstock rather than petroleum feedstock, as they have the same chemical formula.

Nonetheless, the inventors of the ’048 Patent were not the first to disclose this dehydration process, even with renewable bio-materials, such as plant oils. For instance, Le was filed nearly a decade before the ’048 Patent and describes dehydrating “alcohols obtained from the starting materials of renewable origins” with a catalyst to produce 1-alkenes. Ex. 1007 at [0062]-[0063]. Le alone, or combined with De Bruyn’s teachings of this well-known dehydration process for petroleum-derived sources, renders the claims of the ’048 Patent obvious. In addition, one of the inventors of the ’048 Patent, Michael E. Wright, previously filed

a U.S. patent application assigned to the U.S. Government, the Wright '788 Application. The Wright '788 Application specifically refers to its invention as “a method for dehydrating bio-1-alcohol including... heating the bio-1-alcohol with at least one desired catalyst... to produce bio-1-alkene with high selectivity (>95%).” Ex. 1009 at [0018]. This is the same invention as subsequently claimed in the '048 Patent assigned to Patent Owner. In short, Patent Owner sought and obtained claims in the '048 Patent that are broad enough to encompass subject matter already disclosed by the same inventor in his prior patent applications for the U.S. Government.

Therefore, the Board should institute this IPR proceeding and find claims 1-6, 8-10, and 22-28 unpatentable.

II. MANDATORY NOTICES UNDER 37 C.F.R. §42.8(a)(1)

Petitioner satisfies each requirement for *Inter Partes* Review of the '048 Patent pursuant to 37 C.F.R. §42.8(a)(1).

A. Real Party In Interest Under 37 C.F.R. §42.8(b)(1)

The real parties in interest are Symrise AG and Symrise Inc.

Symrise AG's address is:

Mühlenfeldstrasse 1
37603 Holzminden
Germany

Symrise Inc.'s Address is:

300 North Street
Teterboro, NJ 07608

B. Related Matters Under 37 C.F.R. §42.8(b)(2)

Petitioner is not aware of any judicial or administrative proceeding involving the '048 Patent.

C. Lead and Back-Up Counsel Under 37 C.F.R. §42.8(b)(3)

Petitioner is represented by the following counsel:

<u>Lead Counsel</u>	<u>Backup Counsel</u>
James P. Murphy (Reg. No. 55,474) Polsinelli PC 1000 Louisiana Street Suite 6400 Houston, Texas 77002 Telephone: 713.374.1631 jpmurphy@polsinelli.com	Ryan Murphy (Reg. No. 66,285) Polsinelli PC 1401 I St NW Suite 800 Washington DC 20005 Telephone: 202-626-8373 rmurphy@polsinelli.com
	R. James Balls (Reg. No. 57,703) Polsinelli PC 1401 I St NW Suite 800 Washington DC 20005 Telephone: 202-626-8376 jballs@polsinelli.com

Pursuant to 37 C.F.R. §42.10(b), Powers of Attorney have been filed with this Petition.

D. Service Information Under 37 C.F.R. §42.8(b)(4)

Physical mailing service information for lead and backup counsel is as follows:

James Murphy
Polsinelli PC
1000 Louisiana Street
Suite 6400
Houston, Texas 77002

Petitioner also consents to service by e-mail at the above e-mail addresses provided for lead and backup counsel.

E. Payment of Fees Under 37 C.F.R. §42.15

All required fees have been paid with the filing of this Petition. If there are any additional or outstanding fees, Petitioner further authorizes the U.S. Patent & Trademark Office to charge Deposit Account No. 50-1662 for these fees, including the fee set forth in 37 C.F.R. §42.15(a) for this Petition.

F. Certification of Word Count under 37 C.F.R. §42.24(d)

Petitioner certifies that the word count in this Petition, including all footnotes and annotations, is 13,941 words as counted by the word-processing program used to generate this Petition, where such word count excludes the table of contents, mandatory notices, certificate of service, list of exhibits, and this certificate of word count. This Petition is in compliance with the 14,000 word limit set forth in 37 C.F.R. § 42.24(a)(1)(i).

III. REQUIREMENTS FOR IPR UNDER 37 C.F.R. §42.104

A. Grounds for Standing (37 C.F.R. §42.104(A))

Petitioner certifies that the '048 Patent is available for *inter partes* review. Petitioner is not barred or estopped from requesting an *inter partes* review of the '048 Patent claims on the grounds identified in this Petition. 37 C.F.R. §42.104(a).

B. Identification of Claims Being Challenged (37 C.F.R. §42.104(B))

Petitioner asserts that claims 1-6, 8-10, and 22-28 of the '048 Patent are unpatentable based on the following grounds:

Ground	Prior Art	Basis	Claims Challenged
1	U.S. Patent Publication No. 2011/0196114A1 (“Le”)	§103	Claims 1-6, 8-10, 22, 23, and 26-28
2	Le in view of U.S. Patent No. 6,528,665 (“Cheng”)	§103	Claims 24 and 25
3	U.S. Patent Publication. No. 2005/0065389A1 (“De Bruyn”) in view of Le	§103	Claims 1-6, 8-10, 22, 23, and 26-28
4	De Bruyn in view of Le and Cheng	§103	Claims 24 and 25
5	U.S. Patent Publication No. 2012/0238788 to Wright (“Wright ’788”)	§103	Claims 1-6, 8-10, 22, 23, and 26-28
6	Wright ’788 in view of Cheng	§103	Claims 24 and 25

IV. HOW THE CHALLENGED CLAIMS ARE TO BE CONSTRUED UNDER 37 C.F.R. §42.104(b)(3)

In an IPR, claim terms are construed in accordance with the standard set forth in *Phillips v. A.W.H. Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005) (en banc). Further, “claim terms need only be construed ‘to the extent necessary to resolve the controversy.’” *Wellman, Inc. v. Eastman Chem. Co.*, 642 F.3d 1355, 1361 (Fed. Cir. 2011) (quoting *Vivid Techs., Inc. v. Am Sci. & Eng’g, Inc.*, 200 F.3d 795, 048 (Fed. Cir. 1999)).

A. “a carbon chain length about 5 to about 20 carbon atoms”

Independent claim 1 refers to “a carbon chain length of about 5 to about 20 carbon atoms.” The term “about” in claims is a “term of degree” that is definite if the “specification provides examples or teachings that can be used to measure a degree even without precise numerical measurements.” MPEP 2173.05(b) citing *Interval Licensing LLC v. AOL, Inc.*, 766 F.3d 1364, 1371-72, (Fed. Cir. 2014). Furthermore, “[a]ll words in a claim must be considered in judging the patentability of that claim against the prior art.” MPEP 2143.03 citing *In re Wilson*, 424 F.2d 1382, 1385 (CCPA 1970).

Patent Owner purposefully chose the phrase “about 5” to cover additional carbon chain lengths described in the ’048 Patent. Ex. 1001 at Abstract and 29:45-51. A carbon chain length of 6 is already expressly covered by the range of “about 5 to about 20 carbon atoms.” Ex. 1001 at 8:11-19. Therefore, the only additional scope

for coverage by the phrase “about 5 to about 20 carbon atoms” is a carbon chain having a length of 4 carbon atoms to 21 carbon atoms. Ex. 1001 at 8:5-10. The specification supports this interpretation when disclosing it was known to dehydrate 1-butanol, which has a carbon chain length of 4 carbon atoms. Ex. 1001 at 7:1-45, 16:53-58.

Further, during the prosecution of the parent application (U.S. App No 16/262,902, U.S. Patent No. 11,414,365), Patent Owner filed an amendment after allowance under 37 C.F.R. 1.312. Patent Owner amended the claims to replace the phrase “having a carbon chain length of about 8” with the phrase “having a carbon chain length of 7.” Ex. 1006 at 334 (Amendment After Notice of Allowance under 37 C.F.R. §1.312 filed April 21, 2020, in U.S. App No 16/262,902). The Office entered the amendment, finding it did not enlarge the scope of the claims, thereby confirming the term “about,” in relation to the length of a carbon chain, covers one additional carbon atom. *See* Ex. 1006 at 342.

Finally, as a practical matter, the claimed phrase “about 5” necessarily includes 4 carbon atoms because carbon atoms are not divisible, *i.e.*, chemical compounds and reactions require entire carbon atoms, not partial carbon atoms. Ex. 1001 at 8:5-10. Similar language was construed in *Pieczenik v. Dyax Corp.*, 226 F.Supp.2d 314 (D. Mass. 2002). In its analysis, the court noted the word “about” is used in patent claims as a “warning,” signaling that exactitude is not being claimed.

Id. at. 317. The court construed the claimed phrase “from about 4 to about 12 L-amino acid residues” to mean “a range of from 3 to 13 of such residues.” *Id.* at 323. Like carbon atoms, L-amino acid residues are not divisible but exist in discrete units.

Accordingly, the claim limitation “a carbon chain length of about 5 to about 20 carbon atoms” should be construed to mean “a carbon chain length with a minimum of 4 carbon atoms and a maximum of 21 carbon atoms.”

V. OVERVIEW OF THE '048 PATENT

A. Summary of the Disclosure of the Claimed Subject Matter

The '048 Patent generally relates to the field of sustainable antimicrobial compounds that exploit alternate natural and renewable preservation systems for use in compositions applicable to various industries. Ex. 1001 at 1:25-30. Specifically, the specification discusses the “preparation of natural and renewable 1,2-alkanediols, methods for making the natural and renewable 1,2-alkanediols and compositions,” including the 1,2-alkanediols prepared from natural and renewable feedstocks. *Id.* at 1:30-35. The '048 Patent discusses a process for making the precursor product of the 1,2-alkanol, a 1-alkene. *Id.* at 7:64-8:10. Indeed, a method for making a 1-alkene is what is recited in claim 1 of the '048 Patent.

The '048 Patent highlights a need for a “material that is an alternative preservation material, or that may be used in an alternative preservation system that is a 100% natural and renewable (‘sustainable’) feedstock to create an antimicrobial

agent that can be used as or in alternative preservation systems.” *Id.* at 3:21-26. Thus, according to the ’048 Patent, the process for the synthesis of bio-1,2-alkanediols in the ’048 Patent is “natural” in that “preferably all of the carbons in the compound” are also “authentic natural compounds derived from plant sources (algae-, plant-, animal- or biomass-derived) and are non-petrochemically derived (i.e., not derived from a non-renewable resource such as fossil fuel, petroleum or other ‘old’ carbon source).” *Id.* at 7:65-8:4 and 12:40-50.

B. Summary of the Prosecution of U.S. Patent No. 10,995,048

The ’048 Patent was filed on Nov. 13, 2019, as Application No. 16/682,059 (“the ’059 Application”), a continuation of Application No. 16/262,902.

Before examination, a Third-Party Submission was filed on September 8, 2020, and included the following references listed in the Third-Party Information Disclosure Statement (“IDS”):

Type of Reference	Reference - Concise Description
U.S. Patent 9,242,226	Michael E. Wright
U.S. Patent 8,912,373	Michael E. Wright
U.S. Patent 8,450,543	Matthew W. Peters, et al.
U.S. Patent 4,234,752	Yulin Wu
U.S. Publication 2003/0006523	Fuji et al., US 2003/006523 (April 3, 2003).
U.S. Publication 2005/0006238	De Bruyn et al., US 2005/006538 (March 24, 2005).

Non-Patent Literature	Klug et al., Degradation of Hydrocarbons by Members of the Genus Candida, II. Oxidation of n-Alkanes and 1-Alkanes by Candida lipolytica, Journal of Bacteriology, Vol. 93, No. 6, pp 1847-1852.
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Ex. 1005 at 175-187.

The “Concise Description of Relevance,” submitted with the Third-Party Submission, differs from its corresponding IDS. In particular, the concise description includes only four references, two of which are not listed on the corresponding IDS. (e.g., U.S. Patent 9,856,461 to Fortman and Liu et al., “*Hydrogen peroxide-independent production of α -alkenes by OleTJE p450 fatty acid decarboxylase*,” Biotechnology for Biofuels 7:28(2014) are not listed on the corresponding IDS). *Id.* For the remaining references, the “Concise Description of Relevance” includes several “See attached statement” notations. However, no such attachment appears in the record. *Id.* Thus, the record of the prior art references submitted in the Third-Party Submission is incomplete.

The Examiner allowed the claims of the ’059 Application without issuing an Office Action. The Examiner’s Notice of Allowance identifies U.S. Patent No. 7,385,092 to Osterhold et al. (“Osterhold”) as the closest prior art. However, Osterhold does not substantively relate to the claims of the ’048 Patent. The Examiner’s Reason for Allowance is presented below:

Osterhold et al. (US 7,385,092, disclosed by Applicant) appears to be the closest prior art and *discloses a process for the synthesis of diols comprising providing an alkene having a carbon of about 5 to about*

20 carbon atoms and converting the alkene to a 1,2-alkenediol [sic]having a carbon chain length of about 5 to about 20 carbon atoms (Abstract, column 10, Example 4). Osterhold et al. are silent in regard to dehydrating an alcohol by heating.

Ex. 1005 at 206 (emphasis added).

Yet, claim 1 of the '048 Patent is drawn to a method for making a bio-alkene. It is unclear why the Examiner cites a process for making a bio-alkanediol as the closest prior art for a claim directed to making a bio-alkene, given they are different compounds.

VI. OVERVIEW OF THE PRIOR ART

A. Summary of Le

Le was filed as a PCT application with the U.S. Patent and Trademark Office on September 22, 2009, and published on August 11, 2011, as US 2011/0196114. Le is prior art to the '048 Patent under at least 35 U.S.C. §102(a)(1) since it was published prior to the effective filing date of the '048 Patent. *See* Ex. 1007.

Le describes a process of polymerizing an olefin having 6 to 9 carbon atoms from “renewable materials” to produce a polymer. Ex. 1007 at [0002]. Le uses olefins derived from renewable sources. Ex. 1007 at [0007], [0008], [0019], and [0021].

The first step of creating the polymer is to form an olefin. Ex. 1007 at [0062]-[0063]. The olefin is formed using renewable material, a natural resource derived from an animal or plant, which can be “renewed as quickly as it is consumed.” Ex.

1007 at [0037]; *see also* Ex. 1007 at [0050]-[0052]. The renewable materials include an unsaturated fatty acid with “an unsaturation of C=C type.” Ex. 1007 at [0055]. For example, one embodiment of the invention advantageously uses plant oil, preferably ricinoleic acid. Ex. 1007 at [0056].

Le describes obtaining and dehydrating an alpha-alcohol. Ex. 1007 at [0094]-[0100]. The dehydration process is carried out in the presence of a dehydration catalyst, *e.g.*, a gamma-alumina-based catalyst, “in a reactor so as to form a mixture of alkene and water.” Ex. 1007 at [0062]-[0063]. The temperature, *e.g.*, between 250 to 400 °C, and pressure, *e.g.*, partial vacuum, are chosen “such that the alcohol is in vaporized form” during the reaction. The bio-1-alkene is created by dehydrating the alcohol in the alpha position, creating “a single isomer (an alpha-olefin).” Ex. 1007 at [0068].

B. Summary of De Bruyn

De Bruyn was filed as a PCT application with the U.S. Patent and Trademark Office on September 11, 2002, and published on March 24, 2005, as U.S. Patent Publication. No. 2005/0065389. De Bruyn is prior art to the '048 Patent under at least 35 U.S.C. §102(a)(1) since it was published prior to the effective filing date of the '048 Patent. *See* Ex. 1008.

De Bruyn discloses a method beginning with an olefinic compound with a shorter carbon chain length and, through hydroformylation, creates an aldehyde or

alcohol with an increased carbon chain length. Ex. 1008 at [0011]; [0019]-[0020]. Ultimately, the aldehyde or alcohol produced from the hydroformylation reaction is hydrogenated and dehydrated, resulting in a longer-chain alkene (or olefin). Ex. 1008 at [0036]. The dehydration reactions are “known” and can typically be run from 250 to 350 °C and from 0 to 5 bar. Ex. 1008 at [0037]. De Bruyn removes “unwanted products” to purify the 1-alcohol before dehydration. Ex. 1008 at [0026], [0033].

De Bruyn’s dehydration reaction, which forms a 1-alkene, can use a “gamma-alumina or [another] promoted alumina catalyst” to promote dehydration. Ex. 1008 at [0037]. Additionally, De Bruyn utilizes a “vertical pipe reactor” for its dehydration reaction. Ex. 1008 at [0053].

De Bruyn’s reaction can be carried out under varying conditions and reach the same reaction result (as displayed in the examples section). Ex. 1008 at [0040]-[0083]. For example, the dehydration reaction converts 1-hexanol into 1-hexene and 1-octanol into 1-octene with high regioselectivity. Ex. 1008 at [0053]-[0071] and [0072]-[0073].

C. Summary of Wright ’788

Wright ’788 was filed as a U.S. Patent Application on March 29, 2012, and published on September 20, 2012, as US 2012/0238788. Wright ’788 is prior art to

the '048 Patent under at least 35 U.S.C. §102(a)(1) since it was published prior to the effective filing date of the '048 Patent.

Wright '788 relates to conversion of terminal alcohols to corresponding terminal alkenes with high regioselectivity and chemical yields. Ex 1009 at [0003]. Note that high regioselectivity is different from high chemical yields. Wright '788 discloses a catalyst system and process for converting a feed of terminal bio-alcohol in water and producing a corresponding alpha-olefin with 92-99% regioselectivity. Further, the reaction can occur in a single pass over the catalyst system with a chemical conversion of greater than 95%. Ex 1009 at [0008].

Particularly, Wright '788 describes a method for dehydrating bio-1-alcohol with a catalyst to produce bio-1-alkene with high regioselectivity (>95%). Ex. 1009 at [0018].

Wright '788's catalyst can be ZnAl_2O_4 or a "γ-alumina catalyst that has been modified by reaction with base and then modified with an organosilane." Ex. 1009 at [0020]. In some embodiments, the heating step "ranges from temperatures of about 300 °C. to 420 °C." Ex. 1009 at [0022].

D. Summary of Cheng

Cheng was filed as a U.S. Patent Application on April 3, 2002, and issued on March 4, 2003, as U.S. Patent 6,528,665. Cheng is prior art to the '048 Patent under

at least 35 U.S.C. §102(a)(1) since it issued prior to the effective filing date of the '048 Patent.

Cheng describes a method for converting a 1-alkene to an epoxyalkane in the presence of a catalyst. Ex 1010 at 1:11-14. Cheng's process then converts the epoxyalkane to an alkanediol, "especially vicinal alkanediols." Ex 1010 at 1:6-10. The alkanediol produced through the method described in Cheng presents a commercially viable way to "reduce[] odor," which avoids expensive distillation operations. Ex 1010 at 1:23-30.

VII. HOW THE CONSTRUED CLAIMS ARE UNPATENTABLE UNDER 37 C.F.R. §42.104(b)(4)

A. Level of Skill in the Art

In view of the subject matter of the '048 Patent, a person of ordinary skill in the art ("POSITA") would have 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*. Ex. 1002, Declaration of Dr. Taber at ¶16.

B. Overview of the Invalidity Arguments

The '048 Patent claims various aspects of well-known processes for converting a bio-1-alcohol into a corresponding bio-1-alkene. Prior to the '048 Patent, a POSITA seeking a "green" or "natural" version of a bio-1-alkene would look to references like Le or Wright '788, which describe

processes for making bio-1-alkenes from new carbon sources (renewable or green carbon feedstock). Ex. 1002 at ¶21.

For instance, as set out in Le and Wright '788, renewable or green carbon feedstock was routinely processed into bio-1-alcohols having a carbon chain length of four or more carbon atoms. These bio-1-alcohols were then converted via dehydration into corresponding bio-1-alkenes having the same number of carbon atoms. Ex. 1002 at ¶22. A POSITA would understand that the reactions set out in Le and Wright '788 are highly regioselective, generating greater than 95% bio-1-alkene and less than about 5% of impurities. The relevant source and outputs of the methods described in Le and Wright '788 are illustrated below:

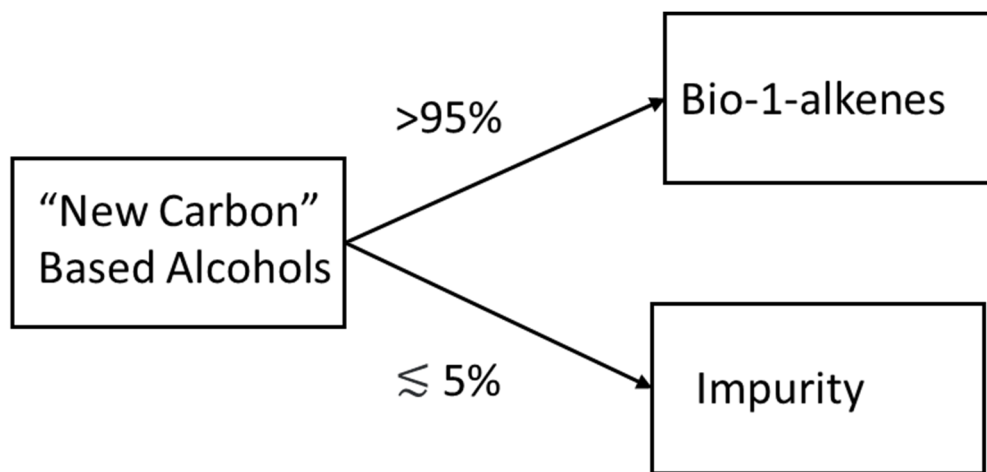


Fig. 1: Illustration of Le and Wright '788 teachings

Accordingly, before the Priority Date of the '048 Patent, a POSITA would expect to successfully obtain bio-1-alkenes with high regioselectivity

by simply dehydrating bio-1-alkenes using well-known methods, as described in detail below. Ex. 1002 at ¶23.

C. New Carbon and Fossil Carbon Compounds Have the Same Properties and Chemical Reactivity

Compounds formed from new carbon atoms will have the same properties and chemical reactivity as compounds formed from fossil carbon atoms. Ex. 1002 at ¶24. The difference between new carbon and fossil carbon is the age of the carbon compounds. *Id.* Two differences between new carbon compounds and fossil carbon compounds are the percentage of carbon-14 (^{14}C) and the percentage of deuterium present in the compounds. Ex. 1002 at ¶25. Fossil carbon compounds contain less ^{14}C than new carbon compounds. The small differences in ^{14}C substitution, less than 1%, will not influence the chemical reactions discussed below or the physical properties of the products of those reactions. Ex. 1002 at ¶25. In other words, the age of the carbon compounds does not alter the chemical reactivity of the compounds or the physical properties of the compounds. Ex. 1002 at ¶25.

Deuterium substitution is the other difference between new and fossil carbon compounds. The deuterium (heavy hydrogen) content of new carbon compounds can differ from fossil carbon compounds by parts-per-million. Ex. 1002 at ¶26. A POSITA would understand that parts-per-million

differences in deuterium substitution would not impact the chemical reactions described below. *Id.*

A POSITA would understand that the choice of new carbon versus fossil carbon starting materials might be driven by many considerations, *e.g.*, marketing, cost, and availability, but would not be based on any fundamental differences in the chemistry. Ex. 1002 at ¶27; *see also* Ex. 1031 and 1032. Indeed, if the starting materials were 100% new carbon, 100% fossil carbon, or a mixture of the two, when used in a reaction, it would have no significant effect on the outcome. Ex. 1002 at ¶27.

A particularly important class of known bio-compounds is bio-alcohols. Ex. 1002 at ¶¶28-29; *see also* Ex. 1020 and 1036. Bio-alcohols are used widely in many products, including fuel, polymers, cosmetics, and other consumer products, *etc.* Ex. 1002 at ¶29. A POSITA would have known before the priority date of the '048 Patent that bio-alcohols were available and could be easily obtained or prepared by a variety of well-known methods. Ex. 1002 at ¶¶29-32; *see also* Ex. 1021, 1022, 1023, 1027.

D. Technology of the '048 Patent

As of the priority date of the '048 Patent, a POSITA would have understood that all of the chemical products and reactions claimed in the '048 Patent were well known and had been well-known for decades. Ex. 1002 at

¶33. The '048 Patent does not explain or identify how or why its chemical products and reactions differ from those known in the art at the time. As discussed above, the use of new carbon has no effect on the proposed chemical reactions, the products of the '048 Patent, or the prior art discussed below. Ex. 1002 at ¶34.

The dehydration of a 1-alcohol (also known as a primary alcohol) to a 1-alkene (also known as a terminal alkene or alpha-olefin) is a well-known and widely studied chemical reaction. Ex. 1002 at ¶35; *see, e.g.*, Ex. 1024, 1035, 1037. This straightforward reaction appears in entry-level organic chemistry textbooks and has been a part of the scientific literature for decades. Ex. 1002 at ¶¶35-40; *see, e.g.*, Ex. 1029, 1030, 1033, and 1034. Further, dehydration reactions have been known for decades and have been practiced on the metric-ton scale. Ex. 1002 at ¶41. The reactions have been optimized for various starting and ending conditions to prioritize the production of 1-alkenes. Ex. 1002 at ¶¶41-46; *see, e.g.*, Ex. 1025, 1026, and 1028. A POSITA would know and understand that commercial-scale dehydration reactions are common and have been carried out for decades and, therefore, well-understood and predictable. Ex. 1002 at ¶47.

E. Claims 1-6, 8-10, 22, 23, and 26-28 are rendered obvious under 35 U.S.C. §103 by Le

1. Summary of the Ground and Reason to Combine

Le renders claims 1-6, 8-10, 22, 23, and 26-28 obvious because it teaches each element of the claims. Furthermore, even though the regioselectivity of Le's reaction is not mentioned explicitly, a POSITA would understand that the dehydration reaction taught by Le would provide bio-1-alkenes at about 95% purity. Ex. 1002 at ¶¶57-61. Furthermore, in light of Le's disclosure and the knowledge of a POSITA, it would be obvious to design a dehydration reaction resulting in predominantly bio-1-alkene. A POSITA would understand this because the high preference for 1-alkene formation from the dehydration of 1-alcohols with γ -alumina catalysts had been known for decades. Ex. 1002 at ¶¶35-40. A POSITA would therefore expect that the conditions of the dehydration reaction taught by Le would lead to the bio-1-alkene product with high regioselectivity, *e.g.*, greater than 95% bio-1-alkene. Ex. 1002 at ¶48.

2. Claim 1

A method for making a bio-alkene comprising: dehydrating a bio-1-alcohol by heating the bio-1-alcohol in a reactor with a catalyst,

Le teaches an alkene/olefin "is obtained from a fatty substance consisting of a plant oil...extracted from renewable resources." Ex. 1007 at [0023]; *see also id.* at [0036]-[0037], [0053]-[0057], [0062]-[0063] (Le's process creates "a mixture of

alkene and water...from the starting materials of renewable origin”), and [0086]-[0089]. In one example, Le explains, “oil comprising ricinoleic acid, preferably castor oil,” is processed to obtain heptan-1-ol (1-heptanol), which is then dehydrated “so as to form 1-heptene.” *Id.* at [0101-0105]. A POSITA understands the alcohol (*e.g.*, 1-heptanol) and the alkene (*e.g.*, 1-heptene) in Le’s method are a bio-1-alcohol and a bio-1-alkene because they are derived from renewable plant oils, rather than petroleum or other fossil fuel sources. Ex. 1002 at ¶¶49, 50; *see also* Ex. 1001 at 13:53-55 (“bio-alkenes may be bio-1-pentene, bio-1-iso-pentene, bio-1-hexene, bio-1-heptene, ...”). Indeed, the ’048 Patent expressly notes that non-petrochemically derived products are known in the art as “bio” products, such as products “derived from the carbon of plant sources.” Ex. 1001 at 3:26-56.

With regards to dehydrating the bio-alcohol, Le teaches:

In order to form the olefin (a) according to the process of the invention, **a dehydration step is carried out in a reactor** so as to form a mixture of alkene and water. This dehydration step can be carried out **in the presence of a dehydration catalyst**, for example a γ -alumina-based catalyst, which may be acidic or basic, in the presence of the **alcohols obtained from the starting materials of renewable origin**.

Ex. 1007 at [0062]-[0063] (emphasis added); Ex. 1002 at ¶51. The alcohol is dehydrated in the reactor by heating it at least within the exemplary temperature range of 250 to 400 °C. Ex. 1007 at [0065] and [0171].

Le also teaches the alcohols for dehydration are obtained from renewable resources such as plant oils. Ex. 1007 at [0027]-[0028], [0053], and [0094]-[0117]. Furthermore, the alkenes produced by dehydrating the bio-1-alcohols are bio-1-alkenes, also known as alpha-olefins or olefins (a). Ex. 1007 at [0027] and [0068]; Ex. 1002 at ¶52. Le's numerous examples disclose dehydrating bio-1-hexanol, bio-1-heptanol, and bio-1-nonanol (all bio-1-alcohols) derived from plant oils into their respective bio-1-alkenes such as bio-1-hexene, bio-1-heptene, and bio-1-nonene. Ex. 1007 at [0094]-[0105], [0110]-[0114], and [0117]; *see also id.* at [0168]-[0174] (example involving dehydrating bio-1-heptanol derived from castor oil to make bio-1-heptene).

Finally, the dehydration catalyst can be γ -alumina, that is acidic, basic, doped, powder, or granules, and has various pore sizes. Ex. 1007 at [0062]-[0064], [0066], [0119], and [0171]; Ex. 1002 at ¶53. Specific examples of commercially available catalysts referenced in Le are "ESM 110®" produced by Eurosupport and "Pural® KR1" produced by Sasol®. Ex. 1007 at [0064] and [0066].

Therefore, a POSITA understands that Le teaches dehydrating a bio-1-alcohol (*e.g.*, bio-1-hexanol to bio-1-nonanol derived from plant oil) by heating the bio-1-alcohol in a reactor (*e.g.*, at 250 to 400 °C) with a catalyst (*e.g.*, a γ -alumina catalyst) to form a bio-1-alkene (*e.g.*, bio-1-hexene, bio-1-heptene, or bio-1-nonene derived from plant oil). Ex. 1002 at ¶¶52, 54.

wherein the resulting bio-alkene has a carbon chain of about 5 to about 20 carbon atoms and a bio-1-alkene regioselectivity of at least about 80%.

Le expressly notes that his invention comprises “an olefin[/alkene], derived from renewable materials, having a number of carbon atoms included in the range of from 6 to 9.” Ex. 1007 at [0002]; *see also id.* at [0007], [0019]-[0020], [0059], and [0117] (all noting Le’s invention comprises producing alkenes with 6 to 9 carbon atoms). As discussed above, Le specifically teaches dehydrating bio-1-hexanol, bio-1-heptanol, and bio-1-nonanol into their respective same carbon chain length bio-1-alkenes such as bio-1-hexene, bio-1-heptene, and bio-1-nonene. Ex. 1007 at [0094]-[0105], [0110]-[0114], and [0117]; *see also id.* at [0168]-[0174] (example involving dehydrating bio-1-heptanol derived from castor oil to make bio-1-heptene). The chain lengths of bio-1-hexene, bio-1-heptene, and bio-1-nonene are 6, 7, and 9 carbons, respectively. Ex. 1002 at ¶55.

While Le does not use the word “regioselectivity,” regioselectivity merely describes the preference of a process to form one specific regioisomer over another regioisomer. Ex. 1002 at ¶56. Le discloses a process that “makes it possible to produce predominantly one olefin with a very limited number of isomers.” Ex. 1007 at [0012] and [0021]; Ex. 1002 at ¶¶57-61. Le also teaches that when a bio-1-alcohol is dehydrated, “a single isomer (an alpha-olefin) is obtained” contrasted to “when the saturated alcohol is not in the alpha-position, a mixture of two isomers is

formed.” Ex. 1007 at [0068]; Ex. 1002 at ¶¶58-59. As previously discussed, alpha-olefin is another term for a 1-alkene. Ex. 1002 at ¶52. Finally, Le provides at least one example where the bio-1-alcohol was purified prior to dehydrating the pure bio-1-alcohol to form a corresponding bio-1-alkene. Ex. 1007 at [0171] (“After separation of 1-heptanol from the other compounds, the 1-heptanol is injected, in order to dehydrate it, ...”), [0172] (“the mixture of water and 1-heptene produced”).

Therefore, a POSITA would understand that even though Le does not use the term regioselectivity, Le’s method of obtaining a single isomer of the bio-1-alkene results in a bio-1-alkene regioselectivity of greater than 95%, which is “at least about 80%.” Ex. 1002 at ¶¶59 (a POSITA would understand that Le’s “single isomer” is at least 95%).

3. Claims 2-4

Claim 2. The method of claim 1, wherein the bio-alkene has a carbon chain of about 6 to about 14 carbon atoms.

Claim 3. The method according to claim 2, wherein the bio-alkene has a carbon chain length of about 6 to about 10 carbon atoms.

Claim 4. The method according to claim 3, wherein the bio-alkene has a carbon chain length of about 6 to about 8 carbon atoms.

Le teaches “an olefin[/alkene], derived from renewable materials, having a number of carbon atoms included in the range of from 6 to 9.” Ex. 1007 at [0002]; *see also id.* at [0007], [0019]-[0020], [0059], and [0117] (Le producing alkenes with 6 to 9 carbon atoms).

As discussed above, Le specifically teaches dehydrating bio-1-hexanol and bio-1-heptanol into their respective same carbon length bio-1-alkene, bio-1-hexene, and bio-1-heptene. Ex. 1007 at [0094]-[0105]; Ex. 1002 at ¶63; *see also* Ex. 1007 at [0168]-[0174] (example dehydrating castor oil derived bio-1-heptanol to bio-1-heptene). The carbon chain lengths of bio-1-hexene and bio-1-heptene are, respectively, six and seven. Ex. 1002 at ¶¶55, 63-64. These carbon chains of six and seven atoms are within the ranges of 6 to 14, 6 to 10, and 6 to 8 carbon atoms recited in claims 2, 3, and 4, respectively. Ex. 1002 at ¶¶63-64.

4. Claim 5

The method according to claim 1, wherein the bio-alkene is bio-octene.

Le teaches that his invention comprises “an olefin[/alkene], derived from renewable materials, having a number of carbon atoms included in the range of from 6 to 9.” Ex. 1007 at [0002]; *see also id.* at [0007], [0019]-[0020], [0059], and [0117] (all noting Le’s invention comprises producing alkenes with 6 to 9 carbon atoms). An olefin with 8 carbon atoms derived from plants, as taught by Le, includes bio-1-octene. Ex. 1002 at ¶65.

Le gives an example of dehydrating bio-2-octanol into a mixture of bio-1-octene and bio-2-octene. Ex. 1007 at [0106]-[0109]. While this specific example of Le uses bio-2-octanol instead of bio-1-octanol, Le’s teachings are not limited to this example. A POSITA would expect a bio-2-octanol to have greater isomerization

during dehydration than a bio-1-octanol, and a POSITA also would understand that Le chose bio-2-octanol for an example because of its easy availability, not because of any technical issue with using bio-1-octanol. Ex. 1007 at [0068]; Ex. 1002 at ¶66. A POSITA would expect a bio-1-octanol used in the process above to produce “a single isomer (an alpha-olefin),” bio-1-octene. Ex. 1007 at [0068]; Ex. 1002 at ¶66. Therefore, a POSITA would understand that if the desired end-product were bio-1-octene (instead of a mixture of bio-1-octene and bio-2-octene), starting with bio-1-octanol would result in the formation of primarily bio-1-octene with in excess of 95% regioselectivity as taught by Le. Ex. 1002 at ¶66.

5. Claim 6

The method according to claim 1, wherein the reactor is a fixed bed reactor.

Le teaches an example using a tubular reactor with a catalytic bed to dehydrate bio-1-heptanol to bio-1-heptene. Ex. 1007 at [0171]. This reactor would be a fixed bed reactor because the catalytic bed is a fixed layer of “ESM110® alumina” within the tubular reactor that promotes the dehydration of the 1-heptanol. Ex. 1002 at ¶67.

6. Claim 8

The method according to claim 1, wherein the catalyst is selected from ZnAl_2O_4 and a γ -alumina catalyst.

Le teaches the catalyst used in the dehydration reaction can be γ -alumina with varying parameters, such as the catalyst being acidic, basic, doped, powder, granules, and having various pore sizes. Ex. 1007 at [0062]-[0064], [0066], [0119],

and [0171]; Ex. 1002 at ¶67. Specific examples of commercially available γ -alumina catalysts used in Le are “ESM 110®” produced by Eurosupport and “Pural® KR1” produced by Sasol®. Ex. 1007 at [0064] and [0066].

7. Claim 9

The method according to claim 1, wherein the bio-alkene has a bio-1-alkene regioselectivity of about 92% to about 99%.

As discussed above with respect to Claim 1, a POSITA would understand that Le’s method to obtain a single isomer of the bio-alkene comprises a bio-1-alkene regioselectivity greater than 95%, which is at least about 92% to 99%. Ex. 1002 at ¶56-60, 69. Accordingly, claim 9 is rendered obvious for the same reasons as discussed with respect to claim 1.

8. Claim 10

The method according to claim 9, wherein the bio-alkene has a bio-1-alkene regioselectivity of about 95% to about 99%.

As discussed above with respect to Claim 1, a POSITA would understand that Le’s method to obtain a single isomer of the bio-alkene comprises a bio-1-alkene regioselectivity greater than 95%, which is at least about 95% to 99%. Ex. 1002 at ¶56-60, 70. Accordingly, claim 10 is rendered obvious for the same reasons as discussed with respect to claim 1.

9. Claim 22

The method according to claim 1, wherein the method comprises a distillation step to refine the bio-alkene.

Le teaches that alpha-olefin/1-alkene can be purified using known techniques, including “a distillation step.” Ex. 1007 at [0067]; *see also id.* at [0173] (example with a step of purifying 1-heptene); Ex. 1002 at ¶¶49, 71.

10. Claim 23

The method according to claim 1, wherein the bio-alkene results from a process wherein the bio-1-alcohol in water is dehydrated by heating the bio-1-alcohol with a catalyst under a purge gas.

Le describes dehydrating a bio-alcohol in the presence of a catalyst under an inert purge gas such as “nitrogen, helium, argon, water, methane, propane, butane, and the other aliphatic or aromatic hydrocarbons.” Ex. 1007 at [0065]-[0066]; Ex. 1002 at ¶72. Water was used earlier in the process, *e.g.*, during the cracking step. Ex. 1007 at [0169]-[0171]. A POSITA would understand that without an explicit drying step, some water would be present in the starting bio-1-alcohol, and Le does not explicitly dry the starting bio-1-alcohol. Ex. 1002 at ¶72. In addition, the bio-1-alcohol will also be in water, at least because the dehydration process generates water in the mixture being dehydrated. Ex. 1007 at [0062] (product of this dehydrating step is alkene and water); Ex. 1002 at ¶72.

11. Claim 26

The bio-alkene made by the method of claim 1.

Le teaches an alkene/olefin “is obtained from a fatty substance consisting of a plant oil...extracted from renewable resources.” Ex. 1007 at [0023]; *see also id.* at [0036]-[0037], [0053]-[0057], [0062]-[0063] (Le’s process creates “a mixture of alkene and water...from the starting materials of renewable origin”) and [0086]-[0089]. In one example, Le teaches, “oil comprising ricinoleic acid, preferably castor oil,” is processed to obtain heptan-1-ol (1-heptanol), which is then dehydrated “so as to form 1-heptene.” *Id.* at [0101]-[0105], [0171]-[0172] (dehydrating 1-heptanol to form a “mixture of water and 1-heptene”). A POSITA understands that the alcohol (*e.g.*, bio-1-heptanol) and the alkene (*e.g.*, bio-1-heptene) formed from the alcohol in Le’s method are a bio-alcohol and a bio-alkene because they are derived from renewable plant oils rather than petroleum or other fossil fuel sources. Ex. 1002 at ¶¶21-23, 73; *see also* Ex. 1001 at 13:53-55 (“bio-alkenes may be bio-1-pentene, bio-1-iso-pentene, bio-1-hexene, bio-1-heptene, ...”). Indeed, the ’048 Patent expressly notes that non-petrochemically derived products are known in the art as “bio” products, such as products “derived from the carbon of plant sources.” Ex. 1001 at 3:26-56.

12. Claim 27

The bio-alkene according to claim 26, wherein the bio-alkene is selected from straight or branched chain bio-alkenes.

Le teaches that his invention comprises “an olefin[/alkene], derived from renewable materials, having a number of carbon atoms included in the range of from 6 to 9.” Ex. 1007 at [0002]; *see also id.* at [0007], [0019]-[0020], [0059], and [0117] (all noting Le’s invention comprises producing alkenes with 6 to 9 carbon atoms). Ex. 1002 at ¶74

As discussed above, Le specifically teaches dehydrating bio-1-hexanol and bio-1-heptanol into their respective same carbon length bio-1-alkene, such as bio-1-hexene and bio-1-heptene. Ex. 1007 at [0094-0105]; *see also id.* at [0168-0174] (for example, dehydrating castor oil-derived bio-1-heptanol into bio-1-heptene). A POSITA understands the “1-hexene” and “1-heptene” nomenclature means that the double bond is between the 1st and 2nd carbon atoms in a straight chain of six and seven carbon atoms, respectively. Ex. 1002 at ¶75. If the carbon chains were branched, cyclical, or other non-linear structure, the name would follow an alternative IUPAC naming convention and not be referred to as 1-hexene or 1-heptene. Ex. 1002 at ¶75.

13. Claim 28

The bio-alkene according to claim 26, wherein the resulting bio-1-alkene is selected from bio-1-pentene, bio-1-iso-pentene, bio-1-

hexene, bio-1-heptene, bio-1-octene, bio-1-nonene, bio-1-decene, and bio-1-dodecene.

Le teaches an invention that comprises “an olefin[/alkene], derived from renewable materials, having a number of carbon atoms included in the range of from 6 to 9.” Ex. 1007 at [0002]; *see also id.* at [0007], [0019]-[0020], [0059], and [0117] (Le producing alkenes with 6 to 9 carbon atoms). Ex. 1002 at ¶76.

As discussed above, Le specifically teaches dehydrating bio-1-hexanol and bio-1-heptanol into their respective same carbon length bio-1-alkene, such as bio-1-hexene and bio-1-heptene. Ex. 1007 at [0094]-[0105]; Ex. 1002 at ¶¶49, 52, 76; *see also* Ex. 1007 at [0168]-[0174] (dehydrating castor oil derived bio-1-heptanol into bio-1-heptene).

Therefore, Le teaches at least the resulting bio-1-alkene is bio-1-hexene and bio-1-heptene, which are both recited in claim 28. Ex. 1002 at ¶¶49, 52, 76.

F. Claims 24 and 25 are rendered obvious under 35 U.S.C. §103 by Le in view of Cheng

1. Reason to Combine

A POSITA would be motivated to combine Le with Cheng because “...vicinal alkanediols, such as 1,2-alkane diols...” taught by Cheng have known commercial applications. *See, e.g.*, Ex. 1010; Ex. 1002 at ¶77; *see also* Ex. 1013. Further, a POSITA would understand that bio-1-alkenes are known chemical precursors to commercial products and that Cheng describes a “commercially attractive way[]” of

using the bio-1-hexene product of Le in the preparation of the vicinal alkanediol. Ex. 1010 at 1:6-10 and 1:40-48. For example, a POSITA would have understood that Le can be combined with Cheng to provide an example of converting 1-hexene to 1,2-epoxyhexane, which is then converted to 1,2-hexanediol. Ex. 1010 at 13:56-14:58 and 16:1-40. Using a known product, *e.g.*, bio-1-alkene, in a known way, *e.g.*, converting to vicinal diols, for known commercial applications would have motivated a POSITA to combine Le with Cheng. Ex. 1002 at ¶77.

2. Claim 24

The method according to claim 1, wherein the bio-alkene is further reacted to form a bio-based compound different from the bio-alkene or a bio-based polymer.

Le describes a process of polymerizing an olefin having 6 to 9 carbon atoms from “renewable materials” to produce a polymer. Ex. 1007 at [0002]; Ex. 1002 at ¶78. Furthermore, it would have been obvious to a POSITA that the alkene produced by Le, *e.g.*, 1-bio-hexene, can be converted to a different bio-based compound. For example, Le can be combined with Cheng, which provides an example for converting a 1-hexene to a 1,2-epoxyhexane, which is then converted to a 1,2-hexanediol. Ex. 1010 at 13:56-14:58 and 16:1-40; Ex. 1002 at ¶78. Combining Le with Cheng would be obvious to a POSITA because “...vicinal alkanediols, such as 1,2-alkane diols...” are used for commercial applications, and Cheng describes a “commercially attractive way[]” of using the hexene product of Le. Ex. 1010 at 1:6-

10 and 1:40-48; Ex. 1002 at ¶¶77-78. These end products are different from bio-alkenes or bio-based polymers.

Therefore, the composition taught by Le in view of Cheng provides a bio-alkene that is different from either the bio-alkene or the bio-polymer formed by that bio-alkene.

3. Claim 25

The method according to claim 24, wherein the bio-alkene is further reacted by a free radical or a catalytic polymerization process to form a bio-based polymer.

Le, in view of Cheng, teaches the alpha olefins/bio-alkenes can be further subjected to catalytic polymerization to form a bio-based polymer. Ex. 1007 at [0019]-[0026], [0036] and [0115]-[0130]; Ex. 1002 at ¶79. In addition, Le states that “free-radical polymerization methods (in an autoclave reactor or a tubular reactor) can also be used.” Ex. 1007 at [0130]; Ex. 1002 at ¶79.

Therefore, Le, in view of Cheng, teaches that bio-alkene is further reacted by a free radical or catalytic polymerization to form a bio-based polymer. Ex. 1002 at ¶79.

G. Claims 1-6, 8-10, 22, 23, and 26-28 are rendered obvious under 35 U.S.C. §103 by Le in view of De Bruyn

1. Summary of the Ground and Reason to Combine

De Bruyn expressly discloses the regioselectivity of his process, but De Bruyn does not disclose using a non-petroleum derived starting material as taught by Le.

However, a POSITA would have understood that the bio-1-alcohol of Le would predictably work in the process of De Bruyn, resulting in a highly regioselective bio-1-alkene product. Ex. 1002 at ¶80. Because the De Bruyn process was known and in use to make metric tons of 1-alkenes for the commercial market, a POSITA would readily consult the literature related to the commercialization of dehydration reactions and rely on a well-known and predictable reaction scheme proven in the market as a starting point for developing an appropriate reaction scheme to produce substantially pure bio-1-alkenes. Ex. 1002 at ¶80.

Le, in view of De Bruyn, renders obvious claims 1-6, 8-10, 22, 23, and 26-28. As discussed above, Le teaches an alkene/olefin “is obtained from a fatty substance consisting of a plant oil...extracted from renewable resources.” Ex. 1007 at [0023]; Ex. 1002 at ¶¶49 and 81; *see also* Ex. 1007 at [0036]-[0037], [0053]-[0057], [0062]-[0063] (Le’s process creates “a mixture of alkene and water...from the starting materials of renewable origin”) and [0086]-[0089]. In one example, Le teaches, “plant oil comprising ricinoleic acid, preferably castor oil,” is processed to obtain heptan-1-ol (1-heptanol), which is then dehydrated “so as to form 1-heptene.” *Id.* at [0101]-[0105]. A POSITA understands that the alcohol (*e.g.*, 1-heptanol) and the alkene (*e.g.*, 1-heptene) in Le’s method are a bio-alcohol and a bio-alkene because they are derived from renewable plant oils rather than petroleum or other fossil fuel

sources. Ex. 1002 at ¶85; *see also* Ex. 1001 at 13:53-55 (“bio-alkenes may be bio-1-pentene, bio-1-iso-pentene, bio-1-hexene, bio-1-heptene, ...”).

A POSITA would understand the advantages of using the natural feedstocks taught by Le with the alkene-generating process taught by De Bruyn. Ex. 1002 at ¶¶82-83. Performing De Bruyn’s dehydration using Le’s bio-1-hexanol or bio-1-octanol would predictably result in bio-1-hexene and bio-1-octene. Ex. 1002 at ¶84. A POSITA would also understand that using alcohol from a natural source, rather than alcohol derived from a petroleum source, would predictably yield a corresponding alkene, *e.g.*, bio-1-hexene or bio-1-octene. Ex. 1002 at ¶¶84, 90. Further, a POSITA would be motivated to use the natural feedstocks of Le for the reasons outlined above, notably marketing, cost, and availability of the materials. Ex. 1007 at [0021]; Ex. 1002 at ¶83. Accordingly, it would be obvious to a person of skill in the art to form a bio-1-alkene using the bio-alcohols of Le with the catalyst and dehydration process of De Bruyn. Ex. 1002 at ¶90.

2. Claim 1

**A method for making a bio-alkene, comprising:
dehydrating a bio-1-alcohol by heating the bio-1-alcohol in a
reactor with a catalyst,**

Le teaches an alkene/olefin “is obtained from a fatty substance consisting of a plant oil...extracted from renewable resources.” Ex. 1007 at [0023]; *see also id.* at [0036]-[0037], [0053]-[0057], [0062]-[0063] (Le’s process creates “a mixture of

alkene and water...from the starting materials of renewable origin”) and [0086]-[0089]. In one example, Le teaches, “plant oil comprising ricinoleic acid, preferably castor oil,” is processed to obtain heptan-1-ol (1-heptanol), which is then dehydrated “so as to form 1-heptene.” *Id.* at [0101]-[0105]. A POSITA understands that the alcohol (*e.g.*, 1-heptanol) in Le’s method is a bio-alcohol because it is derived from renewable plant oils rather than petroleum or other fossil fuel sources. Ex. 1002 at ¶85; *see also* Ex. 1001 at 13:53-55 (“bio-alkenes may be bio-1-pentene, bio-1-isopentene, bio-1-hexene, bio-1-heptene, ...”). Indeed, the ’048 Patent expressly notes that non-petrochemically derived products are known in the art as “bio” products, such as products “derived from the carbon of plant sources.” Ex. 1001 at 3:26-56.

De Bruyn provides several examples of the dehydration reaction using a Sasol® catalyst relied upon by Le. Ex. 1007 at [0066]. In Example 3, De Bruyn describes dehydrating 1-hexanol in a reactor heated to 315 °C with a catalyst of γ -Al₂O₃ to form 1-hexene. Ex. 1008 at [0053]; Ex. 1002 at ¶¶86-88. In Example 4, De Bruyn dehydrates 1-hexanol over a “ γ -alumina catalyst (produced by SASOL Chemie, Pural KR1)” at 290 °C to produce 1-hexene. Ex. 1008 at [0068]-[0071]; Ex. 1002 at ¶88. In Example 5, De Bruyn dehydrates 1-octanol, under the “experimental procedure employed during dehydration, ... as described in example 4 ... [at] a reaction temperature of 280 °C,” to produce 1-octene. Ex. 1008 at [0081]-[0083]; Ex. 1002 at ¶88.

Accordingly, when the bio-1-alcohol of Le is used as the starting material of De Bruyn's dehydration process, the reaction would form a bio-1-alkene with the same chain length as the bio-1-alcohol, *e.g.*, bio-1-hexanol converted to bio-1-hexene and bio-1-octanol converted to bio-1-octene. The combination of Le's bio-based starting material with the dehydration process of De Bruyn leads to the desirable and predictable result of bio-1-alkenes. Ex. 1002 at ¶¶86-88.

wherein the resulting bio-alkene has a carbon chain of about 5 to about 20 carbon atoms and a bio-1-alkene regioselectivity of at least about 80%.

As discussed in Section VI(A) above, Le discloses a known process that "makes it possible to produce predominantly one olefin with a very limited number of isomers." Ex. 1007 at [0012] and [0021]. While Le does not use the word "regioselectivity," regioselectivity merely describes the preference of a process to form a specific isomer. Ex. 1002 at ¶56. Le discloses a known process that "makes it possible to produce predominantly one olefin with a very limited number of isomers." Ex. 1007 at [0012] and [0021]. Le also teaches that when a 1-alcohol is dehydrated, "a single isomer (an alpha-olefin) is obtained," contrasted to "when the saturated alcohol is not in the alpha-position, a mixture of two isomers is formed." Ex. 1007 at [0068]; Ex. 1002 at ¶89. As previously discussed, alpha-olefin is another term for a 1-alkene. Ex. 1002 at ¶52. Finally, Le provides at least one example where the bio-alcohol was purified to a bio-1-alcohol prior to dehydrating the bio-1-alcohol

to form a bio-1-alkene. Ex. 1007 at [0171] (“After separation of 1-heptanol from the other compounds, the 1-heptanol is injected, in order to dehydrate it, ...”), [0172] (“the mixture of water and 1-heptene produced”).

Further, Le expressly describes the Sasol® Pural KR1 catalyst. Ex. 1007 at [0066] and [0068]; Ex. 1002 at ¶90. De Bruyn provides several examples of the dehydration reaction using the same Sasol® catalyst used by Le.

De Bruyn teaches a process of dehydrating alcohols to form more valuable alkenes with additional carbon atoms such as “1-hexene and/or 1-octene.” Ex. 1008 at [0006]; Ex. 1002 at ¶83. De Bruyn describes that “the alcohol isomers formed by the hydroformylation (and optionally hydrogenation) are dehydrated to yield their corresponding olefinic compound isomers.” Ex. 1008 at [0030] and [0033].

De Bruyn describes that “any suitable dehydration process may be used to convert the alcohol with the increased carbon chain length.” Ex. 1008 at [0036]; Ex. 1002 at ¶87. De Bruyn goes further to suggest that “[p]referably the dehydration is carried out under low acidity conditions and a low acidity catalyst support such as Al_2O_3 ; SiO_3 ; TiO_2 or ZrO_2 may be employed to afford a dehydration reaction at temperatures from 250 to 450 °C, typically from 250 to 350 °C.” Ex. 1008 at [0037]; Ex. 1002 at ¶87. For the catalyst, De Bruyn refers to “a gamma-alumina catalyst or a promoted alumina catalyst, *e.g.*, $\text{CaO} \cdot \text{Al}_2\text{O}_3$, $\text{Ca}_2\text{O}_3 \cdot \text{Al}_2\text{O}_3$.” Ex. 1008 at [0037]; Ex. 1002 at ¶87.

De Bruyn provides several examples of the dehydration reaction. In Example 3, De Bruyn describes dehydrating 1-hexanol in a reactor heated to 315 °C with a catalyst of γ -Al₂O₃ to form 1-hexene. Ex. 1008 at [0053]; Ex. 1002 at ¶¶88, 91. In Example 4, De Bruyn dehydrates 1-hexanol over a “ γ -alumina catalyst (produced by SASOL Chemie, Pural KR1)” at 290 °C to produce 1-hexene. Ex. 1008 at [0068]-[0071]; Ex. 1002 at ¶¶88, 92. De Bruyn provides the product obtained from the dehydration of 1-hexanol at 76.5% conversion, as shown below. Note that conversion is different from regioselectivity.

TABLE 10

Analysis of product obtained by the dehydration of 1-hexanol at 76.5% conversion and 7 hours on-stream. Results are expressed on dry-basis.	
Compound	Mass %
3-methyl-1-pentene	0.01
1-hexene	54.21
n-hexane	0.12
trans-3-hexene	0.02
cis-3-hexene	0.03
trans-2-hexene	0.39
cis-2-hexene	1.26
trans-3-methyl-2-pentene	0.15
1-hexanol	26.57
dihexyl ether	17.00
minor components	0.24
Total	100.00

Ex. 1008 at Table 10. A POSITA would understand the dehydration reaction of the bio-1-hexanol in Le produces bio-products in the following mass percentages, as evidenced by De Bruyn: 54.2% 1-hexene; 0.02% trans-3-hexene; 0.03% cis-3-

hexene; 0.39% trans-2-hexene; 1.26% cis-2-hexene. As such, the regioselectivity of the dehydration reaction would be 97.0%, which is the percent of 1-hexene relative to all hexene isomers (*e.g.*, $54.2/(54.2+.02+.03+.39+1.26) = .9695$). Ex. 1002 at ¶¶92 and 96.

In Example 5, De Bruyn dehydrates a bio-1-octanol under the “experimental procedure employed during dehydration, ... as described in example 4 ... [at] a reaction temperature of 280 °C,” to produce bio-1-octene. Ex. 1008 at [0080]-[0083]; Ex. 1002 at ¶93. De Bruyn provides the product obtained from the dehydration of octanol conversion as follows:

TABLE 14

Results from the dehydration of the 1-octanol feed with time-on-stream					
TOS (h ⁻¹)	mass % Conversion	mass % Selectivity to octenes	mass % Selectivity to dioctyl ethers	mass % 1-octene Purity	Corrected mass % purity of 1-octene
1	73.2	56.0	17.9	85.0	97.4
2	69.0	51.4	22.5	85.3	97.6
3	66.3	45.2	27.4	85.3	97.9
4	61.9	40.5	31.0	85.4	98.1
5	60.8	40.2	30.8	85.4	98.2
6	60.1	37.6	33.1	85.4	98.2
7	59.8	36.5	33.9	85.4	98.3
8	59.4	36.4	33.9	85.5	98.3

Ex. 1008 at Table 14; *see also id.* at Figure 2 (showing percentage conversion, yield of octenes, and purity versus time-on-stream).

A POSITA would understand the dehydration reaction using a bio-based alcohol of Le with the catalyst of De Bruyn's and would produce a bio-1-octanol with a regioselectivity of at least 97.4%. Ex. 1008 at Table 14; Ex. 1002 at ¶¶94, 95.

In view of the above, a POSITA would understand that De Bruyn's method of dehydrating 1-heptanol and 1-octanol using a bio-1-heptanol or bio-1-octanol of Le would form a bio-alkene such as bio-1-heptene and bio-1-octene with a regioselectivity of about 97.0 to 97.4%, which is at least about 80%. Ex. 1002 at ¶96.

3. Claims 2-5

Claim 2. The method of claim 1, wherein the bio-alkene has a carbon chain of about 6 to about 14 carbon atoms.

Claim 3. The method according to claim 2, wherein the bio-alkene has a carbon chain length of about 6 to about 10 carbon atoms.

Claim 4. The method according to claim 3, wherein the bio-alkene has a carbon chain length of about 6 to about 8 carbon atoms.

Claim 5. The method according to claim 1, wherein the bio-alkene is bio-octene.

As discussed above, Le teaches a dehydration process of bio-alcohols using the catalyst taught in De Bruyn. De Bruyn teaches a process that forms "1-hexene and/or 1-octene." Ex. 1008 at [0006]; Ex. 1002 at ¶¶87, 97, 98.

De Bruyn provides several examples of the dehydration reaction. In Example 3, De Bruyn describes dehydrating 1-hexanol in a reactor heated to 315 °C with a catalyst of gamma-Al₂O₃ to form 1-hexene. Ex. 1008 at [0053]; Ex. 1002 at ¶¶88, 98. In Example 4, De Bruyn dehydrates 1-hexanol over a "γ-alumina catalyst

(produced by SASOL Chemie, Pural KR1)” at 290 °C to produce 1-hexene. Ex. 1008 at [0068]-[0071]; Ex. 1002 at ¶¶88, 98. In Example 5, De Bruyn dehydrates 1-octanol, under the “experimental procedure employed during dehydration, ... as described in example 4 ... [at] a reaction temperature of 280 °C,” to produce 1-octene.” Ex. 1008 at [0081]-[0083]; Ex. 1002 at ¶¶88, 98.

The carbon chain length of bio-1-hexene is six, and the carbon chain length of bio-1-octene is eight. Ex. 1002 at ¶¶55, 99. Both carbon chain lengths fall within ranges of 6 to 14, 6 to 10, and 6 to 8 carbon atoms recited in claims 2, 3, and 4, respectively. Ex. 1002 at ¶100. A 1-alkene with eight carbon atoms is 1-octene, as recited by claim 5. Ex. 1002 at ¶99.

Additionally, as discussed above with respect to claim 1, a POSITA would be motivated to combine Le’s dehydration reaction with the catalyst and process described in De Bruyn, at least because Le explicitly mentions using the same catalyst in a dehydration reaction with bio-1-heptanol and bio-1-octanol. Ex. 1002 at ¶¶80-84, 90 and 100. A POSITA would expect the bio-1-heptanol and bio-1-octanol of Le to dehydrate under the reaction conditions of De Bruyn to form bio-1-heptene and bio-1-octene. As such, each of claims 2-5 are obvious over the combination of De Bruyn in view of Le.

4. Claim 6

The method according to claim 1, wherein the reactor is a fixed bed reactor.

De Bruyn teaches in Example 3 that a “vertical pipe reactor,” with a “catalyst bed of about 12 grams of gamma- Al_2O_3 ” that “was heated to 315 °C, and 1-hexanol (98% pure) was fed into the reactor.” Ex. 1008 at [0053]; Ex. 1002 at ¶101.

A POSITA would understand this “vertical pipe reactor” as a fixed bed reactor. Ex. 1002 at ¶102. De Bruyn describes a tubular reactor packed with solid gamma- Al_2O_3 catalyst particles. Ex. 1002 at ¶102. Further, De Bruyn does not describe catalyst movement; rather, the catalyst is supported by a bed of quartz wool. Ex. 1002 at ¶102. The vertical pipe reactor is a fixed bed reactor because the catalytic bed is fixed, which promotes the dehydration of the 1-heptanol and/or 1-octanol. Ex. 1002 at ¶102. A POSITA would understand that the vertical pipe reactor of Example 3 could be used for any of the examples of De Bruyn and produce a bio-1-alkene with a greater than 80% regioselectivity. Ex. 1002 at ¶102.

5. Claim 8

The method according to claim 1, wherein the catalyst is selected from ZnAl_2O_4 and a γ -alumina catalyst.

Both Le and De Bruyn describe using a γ -alumina catalyst. Examples 4 and 5 of De Bruyn refer to a “ γ -alumina catalyst (produced by SASOL Chemie, Pural KR1).” Ex. 1008 at [0068]-[0071]; Ex. 1002 at ¶103; see also Ex. 1008 at [0081]

(“The experimental procedure employed during dehydration, was as described in example 4.”); Ex. 1007 at [0062]-[0064], [0066] and [0171]; Claim 9.

6. Claims 9 and 10

Claim 9. The method according to claim 1, wherein the bio-alkene has a bio-1-alkene regioselectivity of about 92% to about 99%.

Claim 10. The method according to claim 9, wherein the bio-alkene has a bio-1-alkene regioselectivity of about 95% to about 99%.

De Bruyn supplements Le to the extent Le neglects to expressly teach or suggest features of claims 9 and 10. As discussed above with respect to claim 1, a POSITA would understand the dehydration reaction of the bio-1-hexanol of Le produces bio-products in the following mass percentages, as evidenced by De Bruyn: 1-hexene at 54.2%; trans-3-hexene at 0.02%; cis-3-hexene at 0.03%; trans-2-hexene at 0.39%; cis-2-hexene at 1.26%. As such, the regioselectivity of the dehydration reaction would be 97.0% bio-1-hexene (*e.g.*, $54.2/(54.2+.02+.03+.39+1.26) = .9695$). Ex. 1008 at Table 10; Ex. 1002 at ¶¶92-95, 104-107.

Likewise, A POSITA would understand that for the target bio-1-octene of Example 5, the dehydration reaction of bio-1-octanol produced bio-1-octene with a regioselectivity of at least 97.4%. Ex. 1008 at Table 14; *see also id.* at Figure 2 (showing percentage conversion, octene yield, and purity versus time-on-stream.); Ex. 1002 at ¶¶92-95, 104-107.

Accordingly, Le, as evidenced by De Bruyn, produces a bio-1-alkene with a regioselectivity above 95%

7. Claim 22

The method according to claim 1, wherein the method comprises a distillation step to refine the bio-alkene.

The combination of Le and De Bruyn teaches a distillation step to refine the bio-1-hexene product. Ex. 1007 at [0067]-[0068]; *see also id.* at [0173] (example of purifying 1-heptene); Ex. 1008 at [0070]; Ex. 1002 at ¶108.

8. Claim 23

The method according to claim 1, wherein the bio-alkene results from a process wherein the bio-1-alcohol in water is dehydrated by heating the bio-1-alcohol with a catalyst under a purge gas.

Le, in view of De Bruyn, teaches that the bio-alcohol is dehydrated in the presence of a catalyst under an inert purge gas such as “nitrogen, helium, argon, water, methane, propane, butane, and the other aliphatic or aromatic hydrocarbons.” Ex. 1007 at [0065]-[0066]; Ex. 1002 at ¶109. The bio-1-alcohol will be in water at least because the dehydration process generates water in the mixture being dehydrated. Ex. 1008 at [0053] (product includes water); Ex. 1002 at ¶109.

9. Claim 26

A bio-alkene made by the method of claim 1.

Claim 26 is rendered obvious for the same reasons as discussed above with respect to claim 1; for example, the method taught by Le in view of De Bruyn makes bio-1-hexene or bio-1-octene. Ex. 1002 at ¶110.

10. Claim 27

The bio-alkene according to claim 26, wherein the bio-alkene is selected from straight or branched chain bio-alkenes.

Claim 27 is rendered obvious for the same reasons discussed above with respect to claim 1. Moreover, Le, in view of De Bruyn, teaches “a process for producing linear unbranched olefins, preferably α -olefins, preferably α -olefins with an even number of carbon atoms, preferably 1-hexene and/or 1-octene.” Ex. 1008 at [0013]; Ex. 1002 at ¶¶74, 75, 111; *see also* Ex. 1007 at [0002], [0007], [0019]-[0020], [0059], and [0117].

11. Claim 28

The bio-alkene, according to claim 26, wherein the resulting bio-1-alkene is selected from bio-1-pentene, bio-1-iso-pentene, bio-1-hexene, bio-1-heptene, bio-1-octene, bio-1-nonene, bio-1-decene, and bio-1-dodecene.

Claim 28 is rendered obvious for the same reasons discussed with respect to claims 1 and 26. In particular, Le, in view of De Bruyn, teaches the bio-alkene is, preferably bio-1-hexene and/or bio-1-octene. Ex. 1007 at [0002], [0007], [0019]-[0020], [0059], and [0117]; Ex. 1008 at [0013] Ex. 1002 at ¶112.

H. Claims 24 and 25 are rendered obvious under 35 U.S.C. §103 by Le in view of De Bruyn and Cheng

1. Summary of the Ground and Reason to Combine

In addition to the reasons to combine Le with De Bruyn, a POSITA would be further motivated to combine Le and De Bruyn with Cheng because “...vicinal

alkanediols, such as 1,2-alkane diols...” taught by Cheng are used for known commercial applications. See, *e.g.*, Ex. 1010; Ex. 1002 at ¶77. Further, a POSITA would understand that bio-1-alkenes are known chemical precursors to commercial products, and Cheng describes a “commercially attractive way[]” of using the bio-1-alkene products of Le in view of De Bruyn as a vicinal alkanediol. Ex. 1010 at 1:6-10 and 1:40-48; Ex. 1002 at ¶113. For example, a POSITA would have understood that Le, in view of De Bruyn, can be combined with Cheng, which provides an example for converting 1-hexene to 1,2-epoxyhexane, which is then converted to 1,2-hexanediol. Ex. 1010 at 13:56-14:58 and 16:1-40. Using a known product, *e.g.*, bio-1-alkene, in a known way, *e.g.*, converting to vicinal diols, for known commercial applications would have motivated a POSITA to combine Le and De Bruyn with Cheng. Ex. 1002 at ¶113.

2. Claim 24

The method according to claim 1, wherein the bio-alkene is further reacted to form a bio-based compound different from the bio-alkene or a bio-based polymer.

Le describes a process of polymerizing an olefin having 6 to 9 carbon atoms from “renewable materials” to produce a polymer. Ex. 1007 at [0002]. Nonetheless, it would have been obvious to a POSITA that the bio-1-alkenes produced by Le in view of De Bruyn, *e.g.*, bio-1-hexene and bio-1-octene, can be converted to a different bio-based compound other than a polymer. Ex. 1002 at ¶114 For example,

Le and De Bruyn can be combined with Cheng, which exemplifies converting a 1-hexene to a 1,2-epoxyhexane, that is then converted to a 1,2-hexanediol. Ex. 1010 at 13:56-14:58 and 16:1-40. Combining Le and De Bruyn with Cheng would be obvious to a POSITA because “...vicinal alkanediols, such as 1,2-alkane diols...” are used for commercial applications, and Cheng describes a “commercially attractive way[]” of using the hexene product of Le in view of De Bruyn. Ex. 1010 at 1:6-10 and 1:40-48; Ex. 1002 at ¶114. These end products are different from the bio-alkenes or bio-based polymers.

Therefore, the composition taught by Le in view of De Bruyn and Cheng results in a bio-based compound that is different than the bio-alkene or a bio-polymer formed from the bio-alkene. Ex. 1002 at ¶114.

3. Claim 25

The method according to claim 24, wherein the bio-alkene is further reacted by a free radical or a catalytic polymerization process to form a bio-based polymer.

Le, in view of De Bruyn and Cheng, teaches that alpha olefins/bio-alkenes are further subjected to catalytic polymerization to form a bio-based polymer. Ex. 1007 at [0019]-[0026], [0036] and [0115]-[0130]; Ex. 1002 at ¶115. In addition, Le states that “free-radical polymerization methods (in an autoclave reactor or a tubular reactor) can also be used.” Ex. 1007 at [0130].

Therefore, Le, in view of De Bruyn, teaches that bio-alkene is further reacted either by a free radical or catalytic-polymerization process to form a bio-based polymer. Ex. 1002 at ¶115.

I. Claims 1-6, 8-10, 22, 23, and 26-28 are rendered obvious under 35 U.S.C. §103 by Wright '788

1. Wright '788 is Prior Art

Wright '788 is prior art to the '048 Patent at least under 35 USC §102(a)(1). Wright '788 is a printed publication published on September 20, 2012, well before the '048 Patent's earliest priority claim of January 30, 2018. Wright '788 at 1 ("Pub. Date: Sep. 20, 2012"). Moreover, because Wright '788 was published more than a year before the earliest priority date to the '048 Patent, there is no exception to Wright '788 as prior art under 35 USC §102(b)(1).

2. Basis for Obviousness

While Wright '788 specifically discloses the regioselectivity for bio-1-butene in an example¹, it does not provide express examples for the regioselective of bio-1-alkene with longer carbon chains. However, a POSITA would understand that

¹ If the Board agrees with Petitioner's claim construction that "about 5" carbon atoms encompasses 4 carbon atoms then Wright '788 disclosure of regioselectivity for bio-1-butene alone is sufficient to show obvious. *Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1373 (Fed. Cir. 2019) ("anticipation is the epitome of obviousness").

Wright's teaching of high regioselectivity would apply to the bio-1-alkenes with longer carbon chains disclosed in Wright '788 up to 23 carbons. Ex. 1002 at ¶116.

3. Claim 1

A method for making a bio-alkene, comprising: dehydrating a bio-1-alcohol by heating the bio-1-alcohol in a reactor with a catalyst,

Petitioner agrees with the Written Opinion of the PCT International Searching Authority that:

Wright ['788] discloses a method for dehydrating a 1-alcohol to a 1-alkene (a method for dehydrating bio-1-alcohol to a bio-1-alkene product; paragraph [0018]), comprising: contacting and heating a 1-alcohol with at least one catalyst (the bio-1-alcohol is subjected and heated to at least one desired catalyst; paragraph [0018]) that comprises a modified inorganic support (catalyst is a gamma-alumina catalyst that has been modified by reaction with base such as sodium or potassium hydroxide; paragraph [0020]) at a WHSV of about 1:01hr⁻¹ to about 10 hr⁻¹ (controlling dwell time a rate of about 0.01 to about 1.0 per mass of said catalyst/hour (WHSV); paragraph [0018]), wherein said 1-alcohol is in a mixture with about 1 ppm to about 93 weight percent water (the bio-1-alcohol having from 1 ppm to 90 percent water; paragraph [0018]), thereby producing the corresponding 1-alkene with

greater than about 90 percent regioselectivity (produce bio-1-alkene with high selectivity of greater than 95 percent; paragraphs [0018], [0034]).

Ex. 1011 at 3; Ex. 1002 at ¶117.

In addition to the analysis and citations provided by the International Searching Authority, Wright '788 characterizes its invention as “a catalyst system and approach that lead to high regiochemical dehydration of 1-bioalcohols” in a reactor chamber to “optimize bio-1-alkene production.” Ex. 1009 at [0027]; *see also* [0016]-[0017] and [0030]; Ex. 1002 at ¶118. In one example, Wright describes “the dehydration of bio-1-butanol” with a γ -alumina catalyst in a fixed-bed continuous flow reactor to produce “bio-1-butene.” Ex. 1009 at [0034]; Ex. 1002 at ¶118.

Finally, the published claims of Wright '788 disclose “[a] bio-1-alkene product, comprising: at least one bio-1-alcohol; at least one desired catalyst, wherein said bio-1-alcohol is subjected and heated to at least one desired catalyst; ...to produce bio-1-alkene product.” Ex. 1009 at Claim 1; Ex. 1002 at ¶119.

Therefore, Wright '788 discloses dehydrating a bio-1-alcohol by heating the bio-1-alcohol in a reactor with a catalyst. Ex. 1002 at ¶120.

wherein the resulting bio-alkene has a carbon chain of about 5 to about 20 carbon atoms and a bio-1-alkene regioselectivity of at least about 80%.

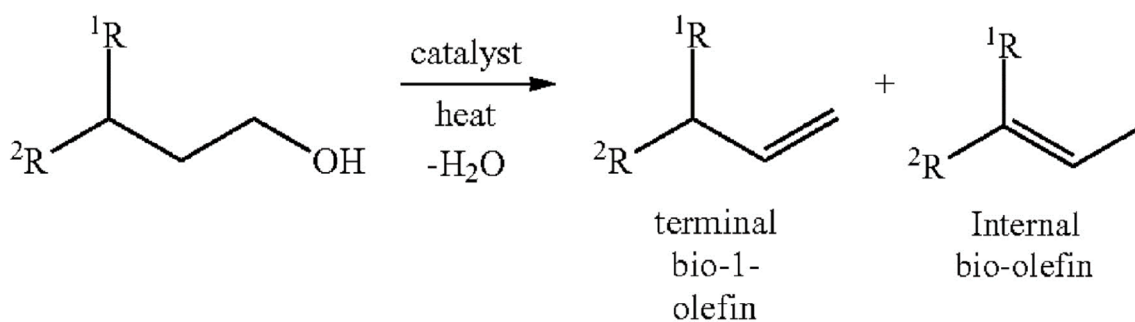
Petitioner agrees with the Written Opinion of the PCT International

Searching Authority that:

Wright [’788] discloses a method for dehydrating a 1-alcohol to a 1-alkene...producing the corresponding 1-alkene with greater than about 90 percent regioselectivity (produce bio-1-alkene with high selectivity of greater than 95 percent; paragraphs [0018], [0034]) ...

Ex. 1011 at 3; Ex. 1002 at ¶121.

Wright ’788 further describes converting bio-1-alcohols into “corresponding” bio-1-alkenes having a chain length of 4 to 23 carbon atoms, as shown below, where ¹R and ²R can be “hydrogen, an alkyl radical of C1 to C20, and any combination thereof.” Ex. 1009 at [0003] and [0016-0017]; Ex. 1002 at ¶122.



Wright ’788 at [0016]

The primary example in Wright ’788 dehydrates bio-1-butanol to bio-1-butene, which has a chain length of 4 carbon atoms. Ex. 1009 at [0027], [0034] and

claim 2; Ex. 1002 at ¶¶122, 124. A chain length of 4 carbon atoms falls within the scope of “about 5” carbon atoms, as explained above in Section V. Wright ’788 includes embodiments describing the dehydration of 1-alcohols having a chain length of 6 carbon atoms (“1-hexanol”) or longer carbon chains lengths of 16 carbon atoms (“1-hexadecanol”). Ex. 1009 at [0022] and claims 11-12; Ex. 1002 at ¶125. A POSITA understands the corresponding terminal alkene for 1-hexanol is 1-hexene because both have a chain length of 6 carbon atoms. Ex. 1002 at ¶122. Wright ’788 also explains, “[e]mbodiments of the invention...produce the respective α -olefin with 92-99% regiochemical selectivity.” Ex. 1009 at [0008], [0016] (“high selectivity (>92%)”), and [0018] (“high selectivity (>95%)”); Ex. 1002 at ¶123. A POSITA understands this high regioselectivity applies to the embodiments with carbon chain lengths between 4 and 23 carbons. Ex. 1002 at ¶122.

A side-by-side comparison of patented claims 1 and 10 of U.S. Patent No. 8,912,373, which issued from Wright ’788, with claim 1 of the ’048 Patent shows that Wright ’788 fully accounts for every element of claim 1 of the ’048 Patent. Compare Ex. 1012 at claims 1 and 10 with Ex. 1001 at claim 1.

US 8,912,373 Filing Date: March 29, 2012 (Claiming Priority to August 26, 2011) Inventors: <u>Michael E. Wright</u>	US 10,995,048 Filing Date: November 29, 2019 (Claiming Priority to January 30, 2018) Inventors: Rocco V. Burgo, <u>Michael E. Wright</u>, Gary B. Mosser, Michael J. Fevola
1. A bio-1-alkene product prepared by the process, comprising: <u>at least one bio-1-alcohol; and</u> <u>at least one base treated protected catalyst at elevated temperatures to produce bio-1-alkene product having a terminal 1-olefin selectivity of about 92% to 99%.</u> <u>10. The product by process according to claim 1, wherein said bio-1-alcohol is 1-pentanol and/or 1-hexanol, renewable alcohols of general formula $HO(CH_2)_n(CH_3)_m$ with $n \geq 2$ and $n+m$ ranging from 3-20, or renewable alcohols of general formula $HO(CH_2)_n(CH_3)$ with n being any integer from 2 to 19.</u>	1. A method for making a bio-alkene, comprising: <u>dehydrating a bio-1-alcohol by heating the bio-1-alcohol in a reactor with a catalyst,</u> <u>wherein the resulting bio-alkene has a carbon chain of about 5 to about 20 carbon atoms and a bio-1-alkene regioselectivity of at least about 80%.</u>

As shown by the above comparison, claims 1 and 10 of U.S. Patent No. 8,912,373, which presumptively have written description support in Wright '788, claim the same subject matter as the '048 Patent. Ex. 1002 at ¶126. This is further evidence that the disclosure of Wright '788 renders obvious claim 1 of the '048 Patent.

4. Claims 2-5

Claim 2. The method of claim 1, wherein the bio-alkene has a carbon chain of about 6 to about 14 carbon atoms.

Claim 3. The method according to claim 2, wherein the bio-alkene has a carbon chain length of about 6 to about 10 carbon atoms.

Claim 4. The method according to claim 3, wherein the bio-alkene has a carbon chain length of about 6 to about 8 carbon atoms.

Claim 5. The method according to claim 1, wherein the bio-alkene is bio-octene

Wright '788 includes embodiments describing dehydration of shorter-chain alcohols, *e.g.*, 1-hexanol, which would produce bio-1-hexene, and longer-chain alcohols, *e.g.*, 1-hexadecanol which would produce 1-hexadecene. 1-hexanol has a chain length of 6 carbon atoms, and 1-hexadecene has a chain length of 16 carbon atoms. Ex. 1009 at [0022] and claims 11-12; Ex. 1002 at ¶127. In addition, Wright '788 confirms that bio-1-alcohols can be converted into “corresponding” bio-1-alkenes of any chain length from 4 through 23 carbon atoms, including bio-1-hexene (six carbon atoms) and bio-1-octene (eight carbon atoms). Ex. 1009 at [0003] and [0016]-[0017]; Ex. 1002 at ¶127.

5. Claim 6

The method according to claim 1, wherein the reactor is a fixed bed reactor.

Wright discloses using a “fixed-bed continuous flow reactor” as one example for implementing his process to dehydrate a bio-1-alcohol to a bio-1-alkene. Ex. 1009 at [0034]; Ex. 1002 at ¶128.

6. Claim 8

The method according to claim 1, wherein the catalyst is selected from ZnAl_2O_4 and a γ -alumina catalyst.

Wright '788 discloses, in some embodiments, the catalyst is “a γ -alumina catalyst,” while in other embodiments, “the catalyst is ZnAl_2O_4 .” Ex. 1009 at [0020], [0024], claim 7, and claims 19-20; Ex. 1002 at ¶129. Wright '788 also teaches the catalyst can be a combination of γ -alumina and zinc oxide (ZnAl_2O_4). Ex. 1009 at [0019], [0022] and claim 21-22.

7. Claims 9 and 10

Claim 9. The method according to claim 1, wherein the bio-alkene has a bio-1-alkene regioselectivity of about 92% to about 99%.

Claim 10. The method according to claim 9, wherein the bio-alkene has a bio-1-alkene regioselectivity of about 95% to about 99%.

As discussed with claim 1, Wright '788 explains, “[e]mbodiments of the invention...produce the respective α -olefin with 92-99% regiochemical selectivity.”

Ex. 1009 at [0008], [0016] (“high selectivity (>92%)”), [0018] (“high selectivity (>95%)”); Ex. 1002 at ¶130. Furthermore, based on the claim construction, including bio-1-butene, the regioselectivity for bio-1-butene is 94-95%. Ex. 1009 at [0034].

8. Claim 22

The method according to claim 1, wherein the method comprises a distillation step to refine the bio-alkene.

Wright '788 discloses distilling the bio-alkene product to refine it by separating it from water. Ex. 1009 at [0032]; Ex. 1002 at ¶131.

9. Claim 23

The method according to claim 1, wherein the bio-alkene results from a process wherein the bio-1-alcohol in water is dehydrated by heating the bio-1-alcohol with a catalyst under a purge gas.

Wright '788 discloses dehydrating a “bio-1-alcohol having from 1 ppm to 90% water, ...with at least one purge gas at a rate of about 0.01 to about 1.0 per mass of said catalyst/hour to produce bio-1-alkene with high selectivity (>95%).” Ex. 1009 at [0018]; Ex. 1002 at ¶132; *see also* Ex. 1009 at [0021-0022] (discussing dehydration of bio-1-alcohol where “the purge gas is nitrogen, argon, or a mixture of the two gases”).

10. Claim 26

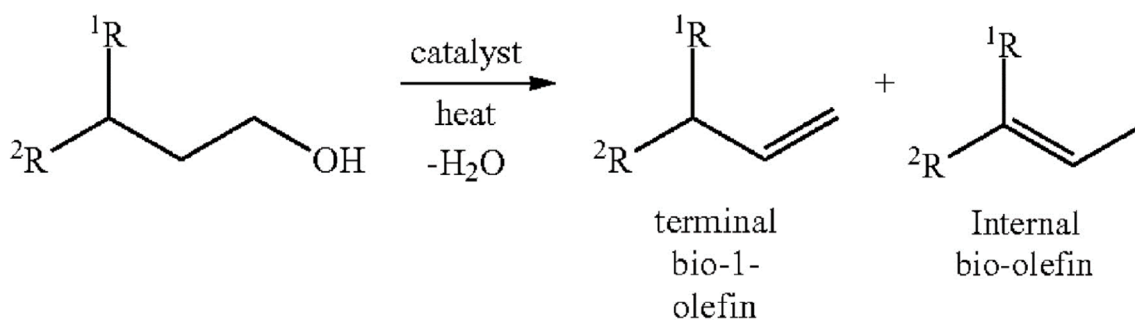
The bio-alkene made by the method of claim 1.

Claim 26 is rendered obvious for the same reasons as discussed above with respect to claim 1, for example the method taught by Wright '788 makes bio-1-alkenes having a chain length of 4 to 23 carbon atoms. See *infra*; Ex. 1002 at ¶133.

11. Claim 27

The bio-alkene according to claim 26, wherein the bio-alkene is selected from straight or branched chain bio-alkenes.

Wright '788 describes converting bio-1-alcohols into “corresponding” bio-1-alkenes having a chain length of 4 to 23 carbon atoms, as shown below, where ¹R and ²R can be “hydrogen, an alkyl radical of C1 to C20, and any combination thereof.” Ex. 1009 at [0003] and [0016-0017]; Ex. 1002 at ¶134.



Wright '788 at [0016]

Furthermore, Wright '788 explains, “the alkyl is selected from the group consisting of methyl, ethyl, propyl, butyl, iso-butyl, and up to C20 alkyl chains as a

pure linear or branched or a mixture thereof.” Ex. 1009 at [0019]. Accordingly, a POSITA understands that these bio-alkenes can be either straight or branched chain bio-alkenes depending on the selection of ¹R and ²R. Ex. 1002 at ¶135.

12. Claim 28

The bio-alkene according to claim 26, wherein the resulting bio-1-alkene is selected from bio-1-pentene, bio-1-iso-pentene, bio-1-hexene, bio-1-heptene, bio-1-octene, bio-1-nonene, bio-1-decene, and bio-1-dodecene.

Claim 28 is rendered obvious for the same reasons as discussed above with respect to claim 1; for example, the method taught by Wright ’788 makes bio-1-alkenes having a chain length of 4 to 23 carbon atoms which includes at least bio-1-pentene, bio-1-hexene, bio-1-heptene, bio-1-octene, bio-1-nonene, bio-1-decene, and bio-1-dodecene. See *infra*; Ex. 1002 at ¶136.

J. Claims 24 and 25 are rendered obvious under 35 U.S.C. §103 by Wright ’788 in view of Cheng

1. Summary of the Ground and Reason to Combine

A POSITA would be motivated to combine Wright ’788 with Cheng because “...vicinal alkanediols, such as 1,2-alkane diols...” taught by Cheng have known commercial applications. See, e.g., Ex. 1010; Ex. 1002 at ¶137; *see also* Ex. 1013. Further, a POSITA would understand that bio-1-alkenes are known chemical precursors to commercial products and that Cheng describes a “commercially attractive way[]” of using the bio-1-alkene products of Wright ’788 to prepare

vicinal alkanediols. Ex. 1010 at 1:6-10 and 1:40-48; Ex. 1002 at ¶137. For example, a POSITA would have understood that Wright '788 can be combined with Cheng to provide an example of converting 1-hexene to 1,2-epoxyhexane, which is then converted to 1,2-hexanediol. Ex. 1010 at 13:55-14:58 and 16:1-40; Ex. 1002 at ¶137. Using a known product, *e.g.*, bio-1-alkene, in a known way, *e.g.*, converting to vicinal diols, for known commercial applications would have motivated a POSITA to combine Wright '788 with Cheng. Ex. 1002 at ¶137

2. Claim 24

The method according to claim 1, wherein the bio-alkene is further reacted to form a bio-based compound different from the bio-alkene or a bio-based polymer.

Wright '788 discloses his invention is used to make “bio-1-alkenes that can be utilized to prepare drop-in and full performance diesel biofuel, jet biofuel, and biolubricants.” Ex. 1009 at [0009] and claims 13-16; Ex. 1002 at ¶138; *see also* Ex. 1009 at [0003]. Furthermore, it would have been obvious to a POSITA that the alkene produced by Wright '788, *e.g.*, 1-bio-hexene, can be converted to a different bio-based compound. Ex. 1002 at ¶138. For example, Wright 788 can be combined with Cheng, which provides an example for converting a 1-hexene to a 1,2-epoxyhexane, that is then converted to a 1,2-hexanediol. Ex. 1010 at 13:55-14:58 and 16:1-40. Combining Wright '788 with Cheng would be obvious to a POSITA because “...vicinal alkanediols, such as 1,2-alkane diols...” are used for commercial

applications, and Cheng describes a “commercially attractive way[]” of using the hexene product of Wright ’788. Ex. 1010 at 1:6-10 and 1:40-48; Ex. 1002 at ¶138. These end products are different from bio-alkenes or bio-based polymers.

3. Claim 25

The method according to claim 24, wherein the bio-alkene is further reacted by a free radical or a catalytic polymerization process to form a bio-based polymer.

Wright ’788, in view of Cheng, further discloses the bio-alkenes can be “contacted with a Ziegler-Natta catalyst to form oligomers.” Ex. 1009 at claims 13-15; Ex. 1002 at ¶139; *see also* Ex. 1009 at [0026] (describing benefits of 1-alkenes for “Zeigler-Natta polymerization”). A POSITA understands that oligomers are considered to be a type of low molecular weight polymer. Ex. 1002 at ¶139. Thus, reacting bio-alkenes with a Zeigler-Natta catalyst to form oligomers is a catalytic polymerization process to form bio-based polymers.

VIII. BOARD SHOULD NOT DENY PETITION UNDER §325(d)

Any argument that the Board should deny this petition under 35 USC §325(d) based on previously presented prior art or arguments should be rejected. The Board analyzes whether to exercise its discretion under §325(d) according to the two-part framework set forth in *Advanced Bionics. Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH*, IPR2019-01469, Paper 6 at 7 (precedential)

(PTAB Feb. 13, 2020) (citing *Becton, Dickinson & Co. v. B. Braun Melsungen AG*, IPR2017-01586, Paper 8 (PTAB Dec. 15, 2017)).

Both steps of the *Advanced Bionics* framework weigh against discretionary denial of this IPR petition, as discussed below. First, most grounds in this petition rely on prior art that was never previously considered by the Office. Second, for the prior art that was previously considered, the Examiner committed clear error, particularly in allowing claims for the '048 Patent that are broad enough to encompass one of the inventors' much earlier patents.

A. First Step of *Advanced Bionics*

The first step under *Advanced Bionics* considers “whether the same or substantially the same art [or arguments] previously was presented to the Office.” *Advanced Bionics* at 7-8. The majority of the grounds in this petition (Ground 1-4) rely on the teachings of Le, which has never been presented to the Office for consideration with respect to the '048 Patent. Le is not cited on the face of the '048 Patent and is not listed in any IDS in the '048 Patent prosecution history record. This *inter partes* review petition is the first instance in which Le has been presented to the Office for consideration with respect to the subject matter claimed in the '048 Patent. Nor does the record indicate any art substantially the same as Le was presented to the Office, such as a patent or PCT equivalent of Le.

Thus, the Office has never considered the teachings of Le with respect to using renewable natural sources to obtain 1-alcohols to dehydrate into 1-alkenes with 6-9 carbons. Ex. 1007 at [0015], [0024]-[0028], and [0037]. Nor has the Office ever considered Le's disclosure that this reaction results in "a single isomer (an alpha-olefin)," which a POSITA understands as teaching a high regioselectivity greater than 95%. Ex. 1007 at [0068]; Ex. 1002 at ¶¶58-61. Grounds 1-4 of this IPR petition rely at least partially on new teachings from Le that the Office has never been previously presented with or considered. Even if aspects of De Bruyn in Grounds 3-4 were previously presented to the Office, the Office has never been presented with the teachings of De Bruyn combined with the teachings from Le.

Grounds 5 and 6 of this IPR petition rely on the teachings of Wright '788 that are substantially the same as those previously presented to the Office. As explained in *Advanced Bionics* step 2, the examiner erred in overlooking the claims of the '048 Patent encompassing the same scope as taught by Wright '788.

Thus, Grounds 1-4 rely on prior art and arguments that have never been previously presented to the Office while Grounds 5-6 rely on prior art and arguments that have been previously presented to the Office. Therefore, on the whole, this Petition is directed to newly presented art and arguments even if certain prior art and argument have been previously presented to the Office. As such, this factor weighs against the discretionary denial of this IPR petition.

B. Second Step of *Advanced Bionics*

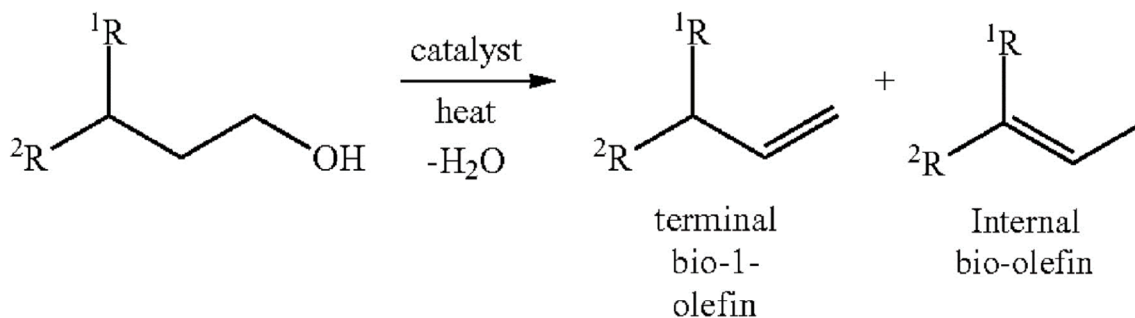
If the Board finds the first step of *Advanced Bionics* is met, then the second step under *Advanced Bionics* considers whether the Examiner “erred in a manner material to the patentability of challenged claims.” *Advanced Bionics* at 8. Here, the only Grounds that would have been previously presented to the Examiner are Grounds 5-6 based on Wright ’788. However, this factor weighs strongly against discretionary denial in view of the Examiner’s clear error with respect to Wright patents are substantially similar to Wright ’788.

The sole inventor of Wright ’788 is Michael E. Wright, who is also one of the inventors for the ’048 Patent. *Compare* Ex. 1009 to Ex. 1001. Yet, Wright ’788 has no legal relationship to the ’048 Patent. Wright ’788 was filed and published six years before the earliest provisional date of the ’048 Patent. *Id.* The patent Wright ’788 matured into was assigned to the United States of America as Represented by the Secretary of the Navy rather than the instant Patent Owner. *See* Ex. 1012.

Assuming the ’048 Patent specification discloses any inventions that are not anticipated or rendered obvious by Wright ’788, **those inventions are not claimed.** Instead, the claims of the ’048 Patent are so broad that they claim the exact same invention disclosed in Wright ’788, as discussed above with respect to how Wright ’788 anticipates the claims of the ’048 Patent. *See* Section XIII(F) *supra*. In particular, Wright ’788 discloses that “the invention relates to a method for

dehydrating bio-1-alcohol including... heating the bio-1-alcohol with at least one desired catalyst... to produce bio-1-alkene with high selectivity (>95%).” Ex. 1009 at [0018]; *see also id.* at [0008], [0016], [0027], and [0030].

This single sentence in Wright ’788 discloses the entirety of claim 1 of the ’048 Patent except for the length of the bio-alkene carbon chain being “about 5 to about 20 carbon atoms.” Yet, Wright ’788 discloses bio-alkenes with carbon chains from 4 to 23 carbons. Ex. 1009 at [0003]. [0016] and [0017]. Wright ’788 gives the general chemical formula for his reaction as shown below, where ¹R and ²R can be “an alkyl radical of C1 to C20.” Ex. 1009 at [0016]-[0017]



Since ²R can have between 1 and 20 carbon atoms, the carbon chain of the terminal-bio-1-olefin shown in the above figure can be from 4 to 23 carbon atoms. Ex. 1002 at ¶¶122-125. Wright ’788 also discloses the “invention generally relates to the conversion of terminal alcohols to the corresponding terminal alkene.” Ex. 1009 at [0003]. Some examples of terminal bio-alcohols provided by Wright are “1-pentanol and/or 1-hexanol,” whose corresponding terminal bio-alkenes would be

bio-1-pentene having five-carbon atoms or bio-1-hexene having six-carbon atoms.
Ex. 1009 at [0022]; Ex. 1002 at ¶¶122-125.

Moreover, it is not just this IPR petition which demonstrates this error, but also the findings of the PCT International Searching Authority in rejecting a different Wright application over Wright '788:

Wright ['788] discloses a method for **dehydrating a 1-alcohol to a 1-alkene** (a method for dehydrating bio-1-alcohol to a bio-1-alkene product; paragraph [0018]), comprising: contacting and heating a 1-alcohol with at least one catalyst (the bio-1-alcohol is subjected and heated to at least one desired catalyst; paragraph [0018]) that comprises a modified inorganic support (catalyst is a gamma-alumina catalyst that has been modified by reaction with base...thereby **producing the corresponding 1-alkene with greater than about 90 percent regioselectivity** (produce bio-1-alkene with high selectivity of greater than 95 percent; paragraphs [0018], [0034]).

Ex. 1011 at 3 (emphasis added). Perhaps most concerning is that this PCT opinion was issued in April 2015, well before the '048 Patent was filed, yet this PCT opinion was never submitted to the Examiner during the prosecution of the '048 Patent.

It is possible the Examiner only focused on the specific example of four-carbon bio-1-butene and overlooked the other disclosure in Wright '788 of producing bio-1-alkenes with five or more carbon atoms. However, this is an error because of Wright '788 disclosure of longer carbon chains, as discussed above.

Moreover, even if Wright '788 only disclosed using his process to produce bio-1-butene, that would still be within the scope of “about 5 to about 20 carbon atoms” since that range includes at least 4 carbon atoms as discussed in the claim construction section, which may have been overlooked by the Examiner.

Finally, the Examiner never considered the additional evidence of the expert declaration submitted with this petition that explains why a POSITA would understand Wright '788 to disclose dehydration of bio-1-alcohols to produce bio-1-alkenes having 4 to 23 carbon atoms. As noted, the Examiner also never considered the PCT Opinion finding the same.

Had the Examiner fully considered Wright '788 and/or had the additional evidence of the attached expert declaration or PCT opinion, the Examiner would not have allowed the claims of the '048 Patent as issued. This material error and these additional facts and evidence weigh strongly against discretionary denial due to the previous presentation of substantially similar prior art as Wright '788.

IX. CONCLUSION

In view of the foregoing, claims 1-6, 8-10, and 22-28 of the '048 Patent are not patentable, and Petitioner requests that IPR be instituted, and these claims of the '048 Patent be canceled.

Date: June 15, 2023

Respectfully submitted,

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CERTIFICATE OF SERVICE UNDER 37 CFR §42.6(e)(4)

The undersigned hereby certifies that a copy of the accompanying Petition for Inter Partes Review, all accompanying exhibits, and the Power of Attorney has been served via Federal Express on June 15, 2023, upon the following correspondence address of record for the '048 Patent:

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