UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Roquette Frères, S.A.,
Petitioner,

v.

Tate & Lyle Ingredients Americas LLC,
Patent Owner.

Case No. Unassigned

U.S. Patent No. 7,608,436

Petition for *Inter Partes* Review of U.S. Patent No. 7,608,436
Under 35 U.S.C. §§ 311–319 and 37 C.F.R. §§ 42.1–.80, 42.100–.123

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1001	U.S. Patent No. 7,608,436 (filed January 25, 2006; issued October 27, 2009) ("'436 Patent") (Patent under *Inter Partes* Review)
1002	Declaration of Dr. Alexei Demchenko
1003	Curriculum Vitae of Dr. Alexei Demchenko
1004	'436 Patent File History: 02/13/2009 Advisory Action
1005	U.S. Patent No. 4,518,581 (filed Sept. 28, 1982; issued May 21, 1985) ("Miyake")
1006	U.S. Patent No. 5,424,418 (filed Oct. 13, 1993; issued June 13, 1995) ("Duflot")
1007	U.S. Patent No. 2,610,930 (filed Apr. 27, 1946; issued Sept. 16, 1952) ("Cleland")
1008	WO 98/41545 (filed internationally on Mar. 19, 1998; published internationally on Sept. 24, 1998) ("Shah")
1009	S.A.S. Craig et al., *Chapter 18: Polydextrose as Soluble Fiber and Complex Carbohydrate*, *in* COMPLEX CARBOHYDRATES IN FOODS (Susan Sungsoo Cho et al. eds., 1999) ("Craig")
1010	U.S. Patent No. 7,638,151 (filed Mar. 10, 2004; issued Dec. 29, 2009) ("Duan")
1011	NEIL A. CAMPBELL & JANE B. REECE, BIOLOGY (6th ed. 2002) (excerpts)
1012	DAVID L. COX & MICHAEL M. NELSON, LEHNINGER PRINCIPLES OF BIOCHEMISTRY (3d ed. 2003) (excerpts)
1013	U.S. Patent No. 2,719,179 (filed Jan. 25, 2951; issued Sept. 27, 1955) ("Mora")
1014	'436 Patent File History: 01/29/2009 Response after Final Action
1015	U.S. Patent No 6,696,563 (filed Dec. 21, 2000; issued Feb. 24, 2004 ("Bengs")
1016	'436 Patent File History: 03/02/2009 Pre-Brief Conference Request

Petitioner's Exhibit No.	**Document**
1017	'436 Patent File History: 07/24/2009 Examiner Interview Summary
1018	File History for EP 1978826, 8/26/2015 Reply to Office Communication
1019	HANDBOOK OF AMYLASES AND RELATED ENZYMES (Amylase Research Society of Japan eds., 1988)
1020	CORN REFINERS ASSOCIATION, NUTRITIVE SWEETENERS FROM CORN (7th ed. 2002)
1021	Library of Congress listing for Craig publication (Ex. 1009), *available at* https://lccn.loc.gov/98055664
1022	Cargill Sweeteners Product Information Sheet: Clearsweet® 95% Dextrose Corn Syrup
1023	Affidavit of Christopher Butler, Office Manager at the Internet Archive, regarding Cargill Clearsweet® Product Information Sheet
1024	U.S. Patent Application 2004/0213882 (filed Feb. 25, 2004) ("Lauridsen")

I. INTRODUCTION

Pursuant to 35 U.S.C. § 311, Roquette Frères, S.A. ("Roquette" or "Petitioner") submits this petition for *inter partes* review ("IPR"), seeking cancellation of claims 1–36 of U.S. Patent No. 7,608,436 ("the '436 Patent," Ex. 1001). These claims are unpatentable under 35 U.S.C. §§ 102 and 103 over the prior art references identified and applied in this petition, none of which was cited during prosecution.

II. MANDATORY NOTICES

Pursuant to 37 C.F.R. § 42.8, Petitioner provides the following mandatory disclosures:

A. Real Parties-in-Interest

Roquette Frères, S.A. is the real party-in-interest.

B. Related Matters

Petitioner submits that there are no related judicial matters. Petitioner is concurrently filing a petition for IPR of a related patent, U.S. Patent No. 8,057,840.

C. Counsel

Petitioner provides the following designation of counsel:

Lead Counsel	Back-up Counsel
David L. Glandorf (Reg. No. 62222) Gibson, Dunn & Crutcher LLP 1801 California St. Denver, CO 80202-4200 Tel: 303-298-5726 dglandorf@gibsondunn.com	Joseph Evall** Gibson, Dunn & Crutcher LLP 200 Park Avenue New York, NY 10166-0193 Tel: 212-351-3902 jevall@gibsondunn.com Daniel J. Thomasch** Gibson, Dunn & Crutcher LLP 200 Park Avenue New York, NY 10166-0193 Tel: 212-351-3800 dthomasch@gibsondunn.com **Neither Mr. Evall nor Mr. Thomasch is admitted to practice before the USPTO, but each plans to file a motion to appear pro hac vice.

A Power of Attorney accompanies this petition in accordance with 37 C.F.R. § 42.10(b). Service via hand delivery or postal mail may be made at the addresses of the lead and back-up counsel above. Petitioner hereby consents to electronic service, and service via electronic mail may be made at the e-mail addresses provided above for the lead and back-up counsel.

III. PAYMENT OF FEES

Pursuant to 37 C.F.R. §§ 42.103 and 42.15(a), $34,600 ($12,200 for review request, $22,400 for post-institution) is being paid via deposit account 501408.

Any additional fees due in connection with this petition may be charged to the foregoing account.

IV. STANDING

Pursuant to 37 C.F.R. § 42.104(a), Petitioner certifies that the '436 Patent is available for IPR and that Petitioner is not barred or estopped from requesting IPR of the claims on the grounds identified herein.

V. IDENTIFICATION OF CHALLENGE AND STATEMENT OF PRECISE RELIEF REQUESTED

Petitioner requests *inter partes* review and cancellation of claims 1–36 of the '436 Patent on one or more grounds under pre-AIA 35 U.S.C. §§ 102 and 103, as set forth below. This petition is accompanied and supported by the Declaration of Alexei Demchenko, Ph.D. (Ex. 1002), his CV (Ex. 1003), and related materials.

VI. THRESHOLD REQUIREMENT FOR *INTER PARTES* REVIEW

Under 35 U.S.C. § 314(a), institution of *inter partes* review requires "a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition." This petition meets this threshold for each of the asserted grounds of unpatentability.

VII. STATEMENT OF REASONS FOR THE RELIEF REQUESTED

The independent claim of the '436 Patent is directed to a process for preparing known compositions containing higher concentrations of non-linear than linear oligosaccharides, by heating known aqueous feed compositions containing at least one monosaccharide or linear oligosaccharide, and contacting such feed compositions with known catalysts. Every aspect of the claimed process and the resulting product compositions was well-known to carbohydrate chemists long before the January 2006 priority date of the '436 Patent.

The dependent claims place additional restrictions on the feed compositions and other process conditions, including the catalyst used, duration of contact with the catalyst, temperature, and pH. As the Examiner correctly recognized during prosecution, such process conditions as "[t]he time of contact with a catalyst, as well as . . . temperature, pH and feed concentrations would have been obviously within the knowledge of the ordinary worker in the field." Ex. 1004 (2/13/2009, Advisory Action) at 4.

Petitioner predicates its challenge on six references. Exs. 1005-1010. Not one of these six references was cited to, or considered by, the Patent Examiner

during the prosecution of the '436 Patent. Each describes one or more processes that render the claims unpatentable based on the following eight grounds:

Ground 1:	Claims 1, 3–4, 7–9, 11, 15, 25–30, and 32 are anticipated by Miyake (Ex. 1005) under section 102(b)
Ground 2:	Claims 1-13, 15-16, 23-30, and 32 are obvious over Miyake in view of a POSA's knowledge under section 103
Ground 3:	Claims 1, 3-9, 11, 13-17, 23-29, and 31-33 are anticipated by Duflot (Ex. 1006) under section 102(b)
Ground 4:	Claims 1-9, 11, 13-29, and 31-33 are obvious over Duflot in combination with Cleland (Ex. 1007) and/or a POSA's knowledge under section 103
Ground 5:	Claims 1-4, 15-18, 23-29, and 31-32 are anticipated by Shah (Ex. 1008) under section 102(b)
Ground 6:	Claims 1-4, 15-18, 23-29, and 31-32 are obvious over Shah in combination with Craig (Ex. 1009) and/or a POSA's knowledge under section 103
Ground 7:	Claims 1-4, 15-29, and 31-32 are obvious over Shah in combination with Craig and Cleland and/or a POSA's knowledge under section 103
Ground 8:	Claim 1-8, 11-16, 23-31, and 34-36 are obvious over Duan (Ex. 1010) in view of a POSA's knowledge under section 103

The Declaration of Dr. Demchenko, an expert in carbohydrate chemistry with more than 29 years of experience, accompanies this petition. Ex. 1002, ¶¶ 1-2.

VIII. STATE OF THE ART

A. Person of Ordinary Skill in the Art

A person of ordinary skill in the art (POSA) in January 2006, the time of the alleged invention of the '436 Patent, typically would have had at least a Master's degree in chemistry or chemical engineering, and at least 2-3 years of experience in carbohydrate synthesis or analysis, or carbohydrate process development work. Someone with less technical education but more practical experience, or more technical education but less practical experience, could also have been a POSA. Ex. 1002, ¶¶ 125-29. A POSA would have been familiar with carbohydrate chemistry, including the structures, uses, syntheses, analyses, and reactions of monosaccharides and oligosaccharides, and the acids and enzymes that catalyze such reactions. *Id.*

B. Scope and Content of the Art Before January 25, 2006

Dr. Demchenko describes the general knowledge of a POSA as of January 25, 2006. Ex. 1002, ¶ 128-29. A POSA would have relied on and applied such

knowledge in reviewing the prior art. *Id*. *See Randall Mfg. v. Rea*, 733 F.3d 1355, 1362 (Fed. Cir. 2013) ("[T]he knowledge of [a POSA] is part of the store of public knowledge that must be consulted when considering whether a claimed invention would have been obvious."); *In re Khan*, 441 F.3d 977, 988 Fed. Cir. 2006) (a POSA possesses the "understandings and knowledge reflected in the prior art").

1. Carbohydrates

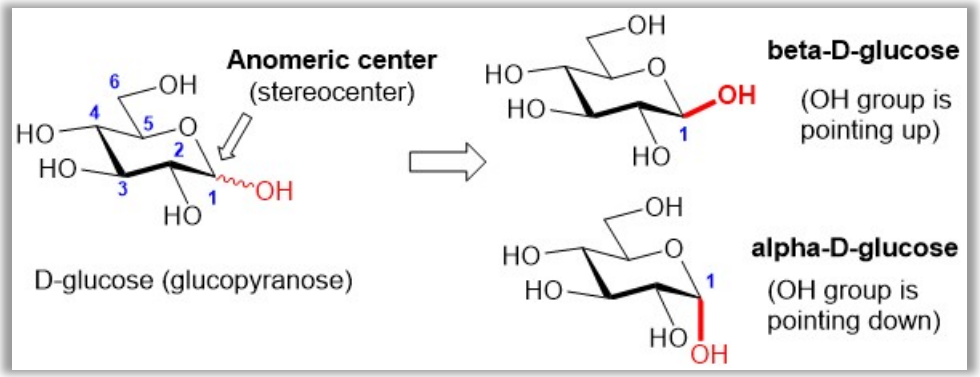
Carbohydrates are polyhydroxy aldehydes and ketones and their derivatives. Ex. 1012 (Lehninger, Principles of Biochemistry) at 293. The class includes sugars, starches, and celluloses.

2. Monosaccharides

Monosaccharides are single-unit sugar molecules, typically containing three to nine carbon atoms. Ex. 1012 at 293. Glucose, the most common monosaccharide, is $C_6H_{12}O_6$ and commonly occurs as a mixture of its open-chain form (which is an aldose because it has an aldehyde group) and as a six-membered ring. *Id*.

The six-membered ring form of glucose is a hemi-acetal because one carbon has a hydroxyl group and an intra-molecular ether linkage. Ex. 1002, ¶ 36; Ex. 1012 at 297. That hydroxyl group may adopt either of two orientations, and each such orientation corresponds to a different compound. Ex. 1012 at 297-98. The

carbon atom attached to this hydroxyl group is the "anomeric center;" the two compounds are alpha and beta "anomers," as shown below:



D-Glucose, also known as dextrose, is naturally-occurring and abundant. Ex. 1012 at 293. L-Glucose, its non-superimposable mirror-image, is rare and must be produced chemically. POSAs would understand "glucose," when not otherwise specified, to mean dextrose, *i.e.* D-glucose. The '436 Patent uses the terms "glucose" and "dextrose" interchangeably. Ex. 1002, ¶ 39.

3. Disaccharides

A disaccharide is two monosaccharide subunits bonded together by a "glycosidic" (also called "glycosyl") linkage, in which the hydroxyl group attached to the anomeric carbon of one monosaccharide and a hydroxyl group from the second monosaccharide are replaced by a single bridging oxygen atom (—O—).

Ex. 1012 at 293. The bridging oxygen atom may be oriented "alpha" or "beta" to the anomeric carbon. Ex. 1002, ¶¶ 36, 41.

A glycosidic linkage is specified by the numbers of the two carbon atoms that it joins, and the orientation with respect to the anomeric carbon. For example, "maltose" is a glucose-glucose disaccharide in which the C-1 anomeric carbon of one glucose unit forms an alpha-glycosidic bond (linkage) with the C-4 of the second glucose unit, creating an "alpha-(1→4) bond," which may be written in several equivalent ways. Alternatively, two units of glucose can form disaccharides through 1→2, 1→3, or 1→6 linkages, and the bond can be alpha or beta. Examples of glucose-glucose disaccharides include:

Kojibiose	alpha-1→2
Nigerose	alpha-1→3
Maltose	alpha-1→4
Isomaltose	alpha-1→6
Cellobiose	beta-1→4

Id., ¶¶ 40-41.

4. Oligosaccharides and Polysaccharides; Degree of Polymerization

An oligosaccharide, or saccharide oligomer,[1] is two or more monosaccharide units (typically 2-30 units) bonded together through glycosidic linkages. Ex. 1001 at 2:54-58. The "degree of polymerization" (or "DP") is the number of monosaccharide units constituting an oligosaccharide or polysaccharide. For example, the DP of trisaccharides, which contain three monosaccharide units, is 3. Ex. 1002, ¶ 42. The molecular weight (MW*)* of an all-glucose oligosaccharide and its DP are related as follows:

$$\mathrm{DP} = \frac{\mathrm{MW} - 180}{162} + 1$$

Ex. 1002, ¶ 56. Polysaccharides such as starch may contain hundreds or thousands of glucose units joined by glycosidic bonds. Adjacent glucose units may be connected by alpha-(1→4) linkages or other linkages (*e.g.*, alpha-(1→6) linkages). *Id.*, ¶ 41.

5. Reducing Sugars

Saccharides that are hemiacetals, aldehydes, hemiketals, and ketones are known as "reducing sugars" because they react with certain test reagents. Ex.

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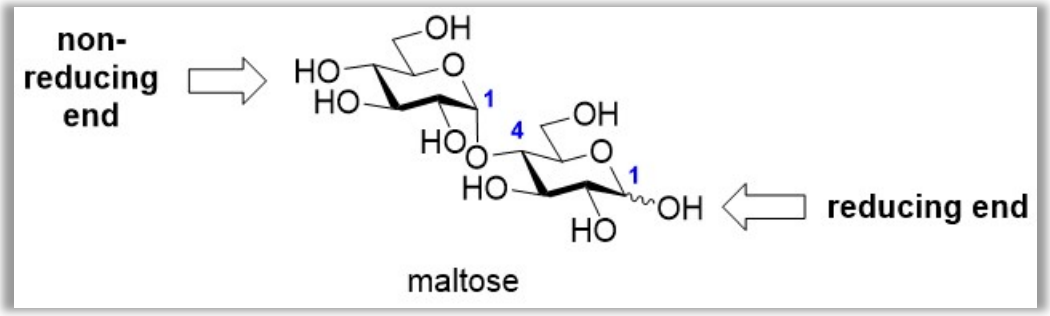
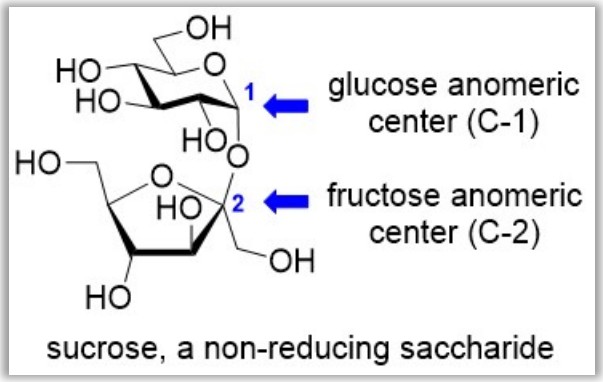
[1] The '436 Patent uses these terms interchangeably. Ex. 1001, at 2:54-58.

1002, ¶ 52. The "reducing end" of a saccharide is the end containing one of the foregoing functional groups. Glucose is a reducing sugar, as it contains a hemiacetal group (in the ring form) or an aldehyde group (in the open chain form). Maltose (a glucose-glucose disaccharide) is a reducing sugar, as it contains a hemi-acetal group. Sucrose (a glucose-fructose disaccharide) is not. *Id*.





6. Dextrose Equivalent

The "Dextrose Equivalent" ("DE") compares the density of "reducing sugar" groups in carbohydrates or mixtures of carbohydrates with an equivalent quantity of glucose. A formula relates the DE of a sample to its molecular weight, so that

DE measurements may be used to calculate molecular weight, and *vice versa*. Ex. 1002, ¶¶ 54-55. The DE of dextrose is 100%. The theoretical DE of maltose and isomaltose (MW = 342 g/mol)—which are each glucose-glucose disaccharides having one reducing end and one non-reducing end—is 52%. *Id*.

Mixtures may be described by their DE. Thus, a "95 DE solution" has 95% of the reducing sugar character of a pure dextrose solution. The DE of non-reducing sugars is zero. *Id*.

7. Reactions of Saccharides

Oligosaccharides are built up through glycosylation reactions (also known as condensation, polymerization, or reversion), and are broken down by hydrolysis. In glycosylation, two saccharide units react to form a glycosidic bond, generating one molecule of water. Ex. 1002, ¶¶ 60-61. Hydrolysis is the reverse reaction, and one molecule of water is consumed for each glycosidic bond that is broken. *Id*., ¶ 59-60.

Glycosylation and hydrolysis reactions may occur in the same system; the reaction conditions determine which process is favored. According to Le Châtelier's Principle, increasing the concentration of the reagents on one side of the reaction helps drive the reaction to the opposite side. *Id*., ¶ 62.

8. Enzymes and Acid Catalysts

Catalysts are used to accelerate the rate of the glycosylation and hydrolysis reactions. Elevated temperatures may also accelerate the reaction rates. Enzymes (*i.e.*, biological catalysts) and acids (including citric acid, phosophoric acid, hydrochloric acid, and sulfuric acid) have been known and used for decades to catalyze glycosylation and hydrolysis reactions. Ex. 1002, ¶ 63.

Enzymes that catalyze the hydrolysis of glycosidic bonds in starch and other poly- or oligo-saccharides are "hydrolases." Common enzymes discussed in the '436 Patent and prior-art references, along with their "Enzyme Commission" (EC) classification numbers, are summarized in the following table. The information in the table was well-known in the art for decades prior to 2006. *Id.,* ¶¶ 63-68. Each of these enzymes catalyzes the hydrolysis of a glycosidic linkage having one or more specific properties, such as the type of linkage, or its location within a poly- or oligo-saccharide. *Id.,* ¶¶ 67-89.

Enzyme (EC number)	**Action**	**Products of hydrolysis**
Alpha-Amylase (EC 3.2.1.1)	Cleaves alpha-(1→4) linkages in oligosaccharides and polysaccharides containing 3 or more alpha-(1→4) linkages, cleaving random fragments from the reducing end of polymeric chains. Does not cleave alpha-(1→6) linkages.	Linear oligosaccharides with DP 3 or more; the reducing end of the free sugar released is "alpha."
Beta-Amylase (EC 3.2.1.2)	Cleaves alpha-(1→4) linkage; acts on the non-reducing end of polymeric chains.	Maltose
Glucoamylase (also known as amyloglucosidase) (EC 3.2.1.3) *Similar to (EC 3.2.1.20)*	Cleaves alpha-(1→4) linkage; Acts on terminal alpha-(1→4) linkages at the non-reducing end. Consecutively removes glucose units from the non-reducing end. Most also cleave alpha-(1→6) linkages when the next bond in the sequence is alpha-(1→4). Does not act on saccharides containing only alpha-(1→6) linkages, or those with two or more such consecutive linkages.	Glucose
Alpha-Glucosidase (EC 3.2.1.20) *Similar to (EC 3.2.1.3)*	Cleaves alpha-(1→4) linkage; Acts on terminal alpha-(1→4) linkages at the non-reducing end. Can catalyze formation of new alpha (1→6) linkages.	Glucose
Invertase (EC 3.2.1.26)	Cleaves fructose residues; Acts on terminal non-reducing fructofuranosides.	Fructose (and catalyzes the hydrolysis of sucrose into fructose and glucose)

Enzyme (EC number)	Action	Products of hydrolysis
Pullulanase (EC 3.2.1.41)	Acts on certain alpha-(1→6) linkages at the branching point. Does not hydrolyze isomaltose, isopanose, or panose. Cannot hydrolyze saccharides having only alpha (1→6) linkages.	Maltose or maltotriose or larger linear oligosaccharides

9. Glycosylation and Oligosaccharide Synthesis

Long before 2006, chemists used acid- and enzyme-catalyzed condensation and hydrolysis reactions to prepare a wide array of oligosaccharides from a broad selection of starting materials. They built up oligosaccharides from glucose, and from linear saccharides such as maltose and maltotriose. They also prepared oligosaccharides through the controlled break-down of starches and other complex carbohydrates. Ex. 1002, ¶¶ 91-99. They also used acids to prepare highly branched oligosaccharides. Ex. 1013 ("Mora") at 1:47-63. For example, they prepared isomalto-oligosaccharides using enzymes that preferentially catalyze the formation of alpha-(1→6) linkages. Ex. 1002, ¶ 98. They also used transglucosidase, which cleaves alpha-(1→4) linkages and forms alpha-(1→6) linkages, to convert maltose to isomaltose or panose. *Id*.

IX. THE '436 PATENT

A. Summary of File History

As filed, claim 1 was directed to the following:

> Claim 1. (Original) A process for preparing saccharide oligomers, comprising:
>
> > heating an aqueous feed composition that comprises at least one monosaccharide or linear saccharide oligomer, and that has a solids concentration of at least about 70% by weight, to a temperature of at least about 40°C; and
> >
> > contacting the feed composition with at least one catalyst that accelerates the rate of cleavage or formation of glucosyl bonds for a time sufficient to cause formation of non-linear saccharide oligomers, wherein a product composition is produced that contains a higher concentration of non-linear saccharide oligomers than linear saccharide oligomers.

Ex**.** 1014 (1/29/2009, Resp. After Final Action) at 3. The Examiner rejected the claims over the Bengs reference (Ex. 1015 (U.S. Patent No. 6,696,563)), which disclosed processing maltodextrin[2] into other types of oligosaccharides. The Examiner found that each limitation in as-filed claim 1 was either disclosed by Bengs or obvious:

> [T]he solid content of the starting material employed would have been within the purview of the ordinary worker to employ concentrations of maltodextrins at least 70% which are heated to temperatures of at least 40 deg C wherein the product formed would yield higher concentrations of non-linear saccharide oligomers.

Ex. 1004 at 3.

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2 Maltodextrin is a polysaccharide prepared by the enzymatic or acidic hydrolysis of starch. Ex. 1002, ¶ 69.

The Examiner also rejected the dependent claims, stating: the "time of contact with a catalyst, as well as the type of catalyst whether enzymatic, acid or combination, temperature, pH and feed concentrations would have been obviously within the knowledge of the ordinary worker in the field." *Id*. at 4.

Applicants argued that Bengs was directed to creating linear glucans (*i.e.*, glucose polysaccharides)—mixtures containing "a lower proportion of non-linear saccharides than linear saccharides." Ex. 1016 (3/2/2009 Pre-Brief Conference Request) at 2, 4.

The Examiner allowed the claim only after it was amended to recite the percentage of non-linear components, finding that "[t]he limitation of claim 27 whereby the concentration of at least 20% branched oligomers would be allowable over the reference of record as approved by Supervisor." Ex. 1017 (7/24/2009 Examiner Interview Summary) at 2. The Examiner then directed the following "Examiner's Amendment":

> In **claim 1, insert in the last line** after "saccharide oligomers" and before the "." the following:
>
> ------ ; wherein the product composition comprises non-linear saccharide oligomers having a degree of polymerization of at least three in a concentration of at least about 20% by weight on a dry solids basis ---- .

Id. at 3. Thereafter the '436 Patent issued, with a priority date of January 25, 2006—its filing date. It does not claim priority to any earlier applications.

The patentee did not submit, and the Examiner did not consider, any of the prior art references that are the subject of this petition. The latest assignment recorded on the PTO website is a September 23, 2014 assignment to Tate & Lyle Ingredients Americas LLC.

B. The '436 Patent Claims

Each of the 36 claims is directed to a "process for preparing saccharide oligomers" having certain properties, from an "aqueous feed composition," using various well-known process steps. Claim 1 is the only independent claim. The following chart lists all claims, with an element-by-element breakdown for independent claim 1:

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[1Pre.] A process for preparing saccharide oligomers, comprising:
[1A.] heating an aqueous feed composition that comprises at least one monosaccharide or linear saccharide oligomer,
[1B.] and that has a solids concentration of at least about 70% by weight,
[1C.] to a temperature of at least about 40ºC;
[1D.] and contacting the feed composition with at least one catalyst that accelerates the rate of cleavage or formation of glucosyl bonds for a time sufficient to cause formation of non-linear saccharide oligomers,
[1E.] wherein a product composition is produced that contains a higher concentration of non-linear saccharide oligomers than linear saccharide oligomers;
[1F.] wherein the product composition comprises non-linear saccharide oligomers having a degree of polymerization of at least three in a concentration of at least about 20% by weight on a dry solids basis.
[2.] The process of claim **1**, wherein the aqueous feed composition comprises at least one monosaccharide and at least one linear saccharide oligomer.
[3.] The process of claim **1**, wherein the aqueous feed composition is a dextrose syrup, a corn syrup, or a solution of maltodextrin.
[4.] The process of claim **1**, wherein at least about 50% by weight on a dry solids basis of the product composition is slowly digestible.
[5.] The process of claim **1**, wherein the feed composition is contacted with the at least one catalyst for at least about five hours.
[6.] The process of claim **1**, wherein the feed composition is contacted with the at least one catalyst for about 15-100 hours.
[7.] The process of claim **1**, wherein the at least one catalyst is an enzyme that accelerates the rate of cleavage or formation of glucosyl bonds.
[8.] The process of claim **7**, wherein the enzyme accelerates the rate of cleavage of alpha 1-2, 1-3, 1-4, or 1-6 glucosyl bonds to form dextrose residues.
[9.] The process of claim **7**, wherein the enzyme is a glucoamylase enzyme composition.
[10.] The process of claim **7**, wherein the amount of enzyme is about 0.5-2.5% by volume of the feed composition.
[11.] The process of claim **7**, wherein the feed composition is maintained at about 55-75ºC during the contacting with the enzyme.
[12.] The process of claim **11**, wherein the feed composition is maintained at about 60-65ºC during the contacting with the enzyme.

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[13.] The process of claim **7**, wherein the feed composition is contacted with the enzyme for about 20-100 hours prior to inactivation of the enzyme.
[14.] The process of claim **13**, wherein the feed composition is contacted with the enzyme for about 50-100 hours prior to inactivation of the enzyme.
[15.] The process of claim **1**, wherein the at least one catalyst is an acid.
[16.] The process of claim **15**, wherein the acid is hydrochloric acid, sulfuric acid, phosphoric acid, or a combination thereof.
[17.] The process of claim **15**, wherein acid is added to the feed composition in an amount sufficient to make the pH of the feed composition no greater than about 4.
[18.] The process of claim **15**, wherein acid is added to the feed composition in an amount sufficient to make the pH of the feed composition about 1.0-2.5.
[19.] The process of claim **15**, wherein the feed composition has a solids concentration of about 70-90% and is maintained at a temperature of about 70-90ºC during the contacting with the acid.
[20.] The process of claim **15**, wherein the solids concentration of the feed composition is at least about 80% by weight, the acid is added to the feed composition in an amount sufficient to make the pH of the composition about 1.8, and the feed composition is maintained at a temperature of at least about 80ºC for about 4-24 hours after it is contacted with the acid.
[21.] The process of claim **15**, wherein the solids concentration of the feed composition is about 90-100% by weight, and the feed composition is maintained at a temperature of at least about 149ºC for about 0.1-15 minutes after it is contacted with the acid.
[22.] The process of claim **21**, wherein the acid comprises a combination of phosphoric and hydrochloric acid.
[23.] The process of claim **1**, wherein the feed composition comprises at least about 75% solids by weight.
[24.] The process of claim **23**, wherein the feed composition comprises about 75-90% solids by weight.
[25.] The process of claim **1**, wherein the product composition comprises non-linear saccharide oligomers having a degree of polymerization of at least three in a concentration of at least about 25% by weight on a dry solids basis.
[26.] The process of claim **25**, wherein the product composition comprises non-linear saccharide oligomers having a degree of polymerization of at least three in a concentration of at least about 30% by weight on a dry solids basis.

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[27.] The process of claim **26**, wherein the product composition comprises non-linear saccharide oligomers having a degree of polymerization of at least three in a concentration of at least about 50% by weight on a dry solids basis.
[28.] The process of claim **1**, wherein the concentration of non-linear saccharide oligomers in the product composition is at least twice as high as the concentration of linear saccharide oligomers.
[29.] The process of claim **1**, wherein the product composition comprises a minor amount of residual monosaccharides, and wherein the process further comprises removing at least some residual monosaccharides from the product composition by membrane filtration, chromatographic fractionation, or digestion via fermentation.
[30.] The process of claim **1**, wherein the at least one catalyst that accelerates the rate of cleavage or formation of glucosyl bonds is enzyme, and the product composition is subsequently contacted with an acid that accelerates the rate of cleavage or formation of glucosyl bonds.
[31.] The process of claim **1**, wherein the at least one catalyst that accelerates the rate of cleavage or formation of glucosyl bonds is acid, and the product composition is subsequently contacted with an enzyme that accelerates the rate of cleavage or formation of glucosyl bonds.
[32.] The process of claim **1**, further comprising hydrogenating the product composition.
[33.] The process of claim **32**, wherein the hydrogenating decolorizes the product composition but does not substantially change its dextrose equivalence.
[34.] The process of claim **1**, further comprising hydrolyzing a maltodextrin to form a hydrolyzed saccharide solution and concentrating the hydrolyzed saccharide solution to at least about 70% dry solids to form the feed composition.
[35.] The process of claim **34**, wherein the concentrating and the contacting of the feed composition with the at least one catalyst occur simultaneously.
[36.] The process of claim **35**, wherein the concentrating occurs prior to the contacting of the feed composition with the at least one catalyst.

X. CLAIM CONSTRUCTION

A claim in *inter partes* review is given its broadest reasonable interpretation ("BRI") in light of the specification. 37 C.F.R. § 42.100(b); *see also Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131 (2016). Petitioner proposes the following BRIs:

1. "aqueous feed composition"

The BRI of "aqueous feed composition" is "a feed composition that contains water." Thus, a feed composition that is "about 90-100% by weight" and contains water is an "aqueous feed composition" within the BRI of the patent claims. *See* Ex. 1001 at 4:45-46; 19:43; 20:51-52.

2. "minor amount"

The BRI of "minor amount" is "less than 50 wt % on a dry solids basis." Ex 1001 at 4:9-12; 5:45-47.

3. "monosaccharide"

The BRI of "monosaccharide" is a "molecule consisting of a single carbohydrate unit," or, equivalently, "a single unit, without glycosidic connection to other such units." Ex. 1002, ¶ 31; Ex. 1012 at 293.

4. "saccharide oligomer" and "Degree of Polymerization"

The terms "saccharide oligomers" and "oligosaccharides" are used

interchangeably in the '436 Patent. The patent defines those terms as follows:

> The terms "oligosaccharides" and "saccharide oligomers" ***are used herein*** to refer to saccharides ***comprising at least two saccharide units***, for example saccharides having a degree of polymerization ("DP") of about 2-30.

Ex 1001 at 2:54-58; 3:62 (characterizing the disaccharide isomaltose an "oligosaccharide"); 6:25-28 (emphasis added).

The BRI of "saccharide oligomer" is a "saccharide comprising at least two saccharide units. The BRI of "Degree of Polymerization" ("DP") is "the number of monosaccharide units present in a saccharide oligomer." Ex. 1002, ¶ 137; *see* also Ex. 1001. at 2:54-58.

5. <u>"non-linear" and "linear" saccharide oligomers</u>

The '436 Patent divides saccharide oligomers into two mutually exclusive groups: non-linear and linear. Accordingly, the broader the definition of "non-linear," the narrower the definition of "linear," and *vice versa*. Because the Board must give the "claim" its "broadest reasonable construction," and because the independent claim of the '436 Patent requires a ***minimum ratio*** of "non-linear saccharide oligomers" to "linear saccharide oligomers," the scope of the claim is broadened by expanding the meaning of "non-linear" oligosaccharides compared to that of "linear." As described in the '436 Patent specification, a "***non-linear***

saccharide oligomer" is a "saccharide oligomer, wherein at least one linkage between saccharide units is not an alpha-(1→4) linkage." Conversely, a "***linear***" oligosaccharide is one containing only alpha-(1→4) linkages. The patent also uses the term "branched" interchangeably with "non-linear." Ex. 1001 at 10:47-52 (emphasis added).

This interpretation of "non-linear" and "linear" ***oligosaccharides*** is consistent with the discussion of non-linear and linear ***linkages*** in the specification of the '436 Patent, which limits linear ***linkages*** to α-1,4 glycosidic bonds:

> Gastrointestinal enzymes readily recognize and digest carbohydrates in which the dextrose units are ***linked alpha (1→4) ("linear" linkages). Replacing these linkages with alternative linkages*** (alpha (1→3), alpha (1→6) (***"non-linear" linkages***) or beta linkages, for example) greatly ***reduces the ability of gastrointestinal enzymes to digest*** the carbohydrate. This will allow the carbohydrates to pass on into the small intestines largely unchanged.

Ex. 1001 at 4:1-9; *see also id.* at 4:60-65; 5:54-58 (emphasis added). The European counterpart to the '436 Patent also contains the foregoing paragraph, which the patentees explained with precision:

> The most logical, and obvious, interpretation of the above is that a linear saccharide would consist of linear linkages, ***whilst a non-linear saccharide would contain one or more non-linear linkages***.

Ex. 1018 (8/26/2015 Reply to Office Communication, EP 1978826) at 2 (emphasis

added).

Patentees' further discussion of that same paragraph again underscored this dichotomy:

> [T]he person of ordinary skill in the art would understand "linear saccharide oligomers" to include only "linear" linkages, *i.e.*, only 1→4 alpha linkages. ***As a matter of logic, anything that is not a "linear saccharide", i.e., linked solely by 1→4 alpha linkages, which would include at least one linkage that is not a 1→4 alpha linkage, must be a "non-linear saccharide."***

Id. at 2 (emphasis added).

Further confirming the foregoing definitions, the '436 Patent expressly classifies two oligosaccharides (maltose and maltotriose) that have ***exclusively*** α1→4 linkages as "linear," and two oligosaccharides (isomaltose and panose) that contain ***at least one*** α1→6 linkage as "non-linear." Ex. 1002, ¶ 46; Ex. 1001 at 3:61-62, 8:1-5, 10:47-53. Nowhere does the '436 Patent characterize an oligosaccharide as "linear" or "non-linear" in a manner inconsistent with the proposed BRI.

The following chart classifies some oligosaccharides referenced herein based on their structure and the proposed BRI:

DP	Name	Glycosidic Linkages	Linear	Non-Linear
2	Maltose	Glc(α1→4)Glc	x	
2	Isomaltose	Glc(α1→6)Glc		x
3	Maltotriose	Glc(α1→4)Glc(α1→4)Glc	x	
3	Isomaltotriose	Glc(α1→6)Glc(α1→6)Glc		x
3	Panose	Glc(α1→6)Glc(α1→4)Glc		x
3	Isopanose	Glc(α1→6)Glc(α1→4)Glc		x
4	Maltotetraose	Glc(α1→4)Glc(α1→4)Glc(α1→4)Glc	x	
4	Isomaltotetraose	Glc(α1→6)Glc(α1→6)Glc(α1→6)Glc		x
5	Maltopentaose	Glc(α1→4)Glc(α1→4)Glc(α1→4)Glc(α1→4)Glc	x	
5	Isomaltopentaose	Glc(α1→6)Glc(α1→6)Glc(α1→6)Glc(α1→6)Glc		x

Ex. 1002, ¶¶ 46-50.

6. <u>"slowly digestible"</u>

The '436 Patent defines the term "slowly digestible" by reference to the human digestive tract:

> "Slowly digestible" as the term is used herein means that one or more carbohydrates are either not digested at all in the human stomach and small intestine, or are only digested to a limited extent.

Ex. 1001 at 2:35-38; *see also id.* at 5:59-63. This definition constitutes the BRI of "slowly digestible."

Petitioner recognizes that the specification purports to define "'at least about 50% by weight on a dry solids basis' of a material being 'slowly digestible'" as meaning that "the sum of the percentages of that material that are classified as slowly digestible or as resistant by the Englyst assay totals at least about 50%." *Id.* at 2:45-49. The quoted statement, however, reflects only one non-exclusive means of proving whether a sample composition meets the "slowly digestible" claim limitation. The patent indicates that the *in vitro* Englyst assay "***can be used to estimate*** the amounts of a carbohydrate ingredient that are rapidly digestible, slowly digestible and resistant to digestion"—*i.e.*, the test is one possible proxy for what happens in a human digestive tract. *Id*. at 2:41-43 (emphasis added). But the '436 patent does not require that the Englyst assay or any other specific test be used to determine whether a sample meets the "slowly digestible" claim element. The means by which one may prove that a composition is slowly digestible, whether by *in vitro* testing, *in vivo* testing, or through structural analysis, is a separate question from what constitutes the BRI of the term.

The specification identifies many oligosaccharides as "slowly digestible" based solely on their chemical structures:

> The product comprises a plurality of saccharides which are slowly or incompletely digested by humans, if not totally indigestible. These sugars can include ***isomaltose***, ***panose*** and ***branched oligomers having a degree of polymerization of four or greater***.

Ex. 1001 at 8:1-5; *see also id.* at 4:1-9 (emphasis added). The oligosaccharides recognized in the patent as "slowly digestible" thus include isomaltose and panose, as well as isomaltotetraose, isomaltosyl maltose, isomaltopentaose, and polydextrose, all of which are "branched oligomers having a degree of polymerization of four or greater." Ex. 1002, ¶¶ 46, 102.

XI. ADDITIONAL PRIOR ART CONFIRMING THE POSA'S GENERAL KNOWLEDGE

In addition to discussing how six prior art references anticipate and/or render obvious the challenged claims of the '436 Patent, Dr. Demchenko also discusses how certain references confirm his opinions regarding the general knowledge of a POSA in January 2006.

In particular, Dr. Demchenko discusses U.S. Patent No. 2,610,930 ("Cleland") (Ex. 1007), which was published on September 16, 1952. As Dr. Demchenko explains, Cleland provides evidence that fifty years before January

2006, POSAs were familiar with dextrose polymerization using different acid catalysts, pH variations, and feed compositions. Ex. 1002, ¶¶ 94-97. For example, Cleland states that "[v]arious acids may be employed to reduce the ***pH of the dextrose solution to a value of 0.5 to 4.5***. Hydrochloric acid is preferred but sulfuric acid, ***phosphoric acid***, . . . or any acid capable of reducing the pH of the solution to the desired amount may be employed." Ex. 1007 at 3:42-48 (emphasis added). Furthermore, Cleland illustrates that POSAs knew that high-concentration corn syrups could be used as starting materials to make carbohydrate products, under acidic conditions at high temperatures. *Id*. at 4:6-13; 4:65-72; Ex. 1002, ¶ 96.

Dr. Demchenko also discusses U.S. Patent No. 2,719,179 ("Mora") (Ex. 1013), which was published in 1951. Mora reflects the POSA's knowledge that aqueous dextrose solutions (including those with 70% solids concentration by weight) could be used as feed compositions and heated to form products containing non-linear oligosaccharides. Mora also reflects the POSA's knowledge that acid catalysts such as hydrochloric acid, phosphoric acid, sulfuric acid, and other acids could be used to catalyze such reactions. Ex. 1013 at 3:3-9. The products

prepared by Mora were non-linear, with a majority of ***non***-alpha-(1→4) linkages, and with DP of greater than 3. *Id*. at 3:60-62; *see also id*. at 5:21-24; 5:40-50.

Dr. Demchenko's opinions that POSAs in 2006 knew the product compositions and process details in the '436 Patent's claim limitations are based not only on his own knowledge and experience, but also on early art such as Mora and Cleland. Ex. 1002, ¶¶ 91-97. His opinions are consistent with the statement articulated by the Patent Examiner during prosecution, with which he agrees: "The time of contact with a catalyst, as well as . . . temperature, pH and feed concentrations would have been obviously within the knowledge of the ordinary worker in the field." Ex. 1004 at 4.

XII. GROUNDS FOR UNPATENTABILITY

Under 35 U.S.C. § 102, if a single prior art reference discloses each limitation of the claimed invention, a patent claim is anticipated and invalid. *Schering Corp. v. Geneva Pharmaceuticals*, 339 F.3d 1373, 1377 (Fed. Cir. 2003). Because the claims at issue include the transitional word "comprising," a single reference may anticipate a claim even if it discloses additional, non-recited steps. *See Smith & Nephew, Inc. v. Ethicon, Inc.*, 276 F.3d 1304, 1311 (Fed. Cir. 2001). Here, a single reference that discloses additional processing after an intermediate

"product composition is produced," or processing before a mixture becomes a feed composition, may anticipate claims of the '436 Patent that do not recite such steps. *See* Ex. 1001 at 3:10-23; 6:3-25. Ex. 1002, ¶¶ 138-140.

Under 35 U.S.C. § 103, a patent claim is obvious and invalid "if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." Multiple pieces of prior art render the challenged claims of the '436 Patent anticipated and/or obvious.

In the following discussion, brackets are used to identify claim elements (*e.g.*, "[1E]") and claim numbers (*e.g.*, "[2]"). The full text of the claims can be found above in section IX.B.

A. Grounds 1-2: Miyake (Ex. 1005) as Primary Reference

U.S. Patent No. 4,518,581 ("Miyake") (Ex. 1005) published on May 21, 1985, and is prior art to the '436 Patent under 35 U.S.C. § 102(b). Miyake was not considered by the Examiner during prosecution. Miyake discloses enzyme-catalyzed processes for using glucose solutions to prepare oligosaccharides that

can be used to sweeten food and drink without creating the risk of dental caries posed by sucrose. Ex. 1005 at Abstract; 1:33-60.

Example 3 describes the preparation of a "low-cariogenic sweetener" by heating an aqueous glucose solution in acidic conditions. Unless otherwise stated, each disclosure below is from that example. *Id.* at 9:5-34.

Ground 1 of this petition is that Miyake anticipates claims 1, 3-4, 7-9, 11, 15, 25-30, and 32. Ground 2 is that Miyake, plus a POSA's knowledge, renders obvious claims 1-13, 15-16, 23-30, and 32.

1. Miyake discloses each element of claim 1

[1Pre]: Miyake discloses preparation of a product with isomaltose, isomaltotriose, isomaltotetraose, and "higher oligosaccharides"—*i.e.*, "saccharide oligomers." Ex. 1005 at 9:28-32; *see also id* at Abstract.

Elements [1A]-[1C]: Miyake discloses heating a feed composition of "70 w/w% aqueous glucose solution" (*i.e.*, one in which 70% of the total weight is attributed to glucose, a solid) to 50ºC. Ex. 1005 at 9:8-14; Ex. 1002, ¶¶ 145-47.

Element [1D]: Miyake acidifies the mixture to pH 4.8 and contacts the feed composition with glucoamylase, an enzyme catalyst, for a time sufficient to cause formation of a product with "isomaltotriose content of 10.2%." Ex. 1005 at 9:10-

14. The '436 Patent acknowledges that "glucoamylase" is a suitable catalyst to accelerate cleavage or formation of glucosyl bonds. Ex. 1001 at 3:30-35; 7:47-49; 20:13-14. Ex. 1002, ¶ 148. Isomaltotriose is a DP3 "non-linear" oligosaccharide. Ex. 1002, ¶ 48.

Element [1E]: Miyake further processes the mixture, obtaining a product with the composition shown in the first two columns of the following chart:

Component	Weight %	Structure	DP	Non-Linear
Glucose	4.2%	Glucose ("Glc")	1	
Isomaltose	32.6%	Glc(α1→6)Glc	2	x
Isomaltotriose	34.5%	Glc(α1→6)Glc(α1→6)Glc	3	x
Isomaltotetraose	19.6%	Glc(α1→6)Glc(α1→6)Glc(α1→6)Glc	4	x
Higher oligosaccharides including isomaltopentaose	9.1%	(Various)	≥5	---

Ex. 1005 at 9:29-32; Ex. 1002, ¶ 149. The total concentration of non-linear oligosaccharides is at least 86.7% (isomaltose + isomaltotriose + isomaltotetraose) of the product by weight. Ex. 1002, ¶ 149.

Element [1F]: Isomaltotriose and isomaltotetraose, non-linear oligosaccharides with DP at least three, comprise 54.1% of the product by weight on a dry solids basis. *Id.,* ¶ 150.

To the extent that the Board determines that Miyake does not sufficiently disclose any element of claim [1], a POSA would readily provide additional detail using the POSA's working knowledge, as described above. *Id.,* ¶¶ 171-72.

2. Miyake anticipates and/or renders obvious the dependent claims

Each claim below ultimately depends from independent claim [1], the elements of which Miyake explicitly discloses. In addition, many dependent claim limitations pertain to routine adjustments of processing conditions, such as concentrations, reaction time, and temperature. Such adjustments were well within the purview of a POSA, as explained by Dr. Demchenko, and as recognized by the Examiner during prosecution of the '436 Patent: "The time of contact with a catalyst, as well as . . . temperature, pH and feed concentrations would have been obviously within the knowledge of the ordinary worker in the field." Ex. 1004 at 4; Ex. 1002, ¶ 172.

Claim [2]: A POSA would understand that if the process is effective for a feed composition containing a monosaccharide, and for a feed composition containing at least one linear saccharide oligomer, then it would be effective for a feed composition containing a mixture of both. Miyake teaches that the process is effective for a feed composition containing the monosaccharide glucose. Ex. 1005

at 9:9. Miyake also teaches that the process is effective for a feed composition containing the linear oligosaccharide maltose, either on its own (*id.* at 6:31-42), or by treating pullulan with glucoamylase. *Id.* at 7:57-65; Ex. 1002, ¶ 173. "Combining two embodiments disclosed adjacent to each other in a prior art patent does not require a leap of inventiveness." *Boston Sci. SciMed Inc. v. Cordis Corp.*, 554 F.3d 982, 991 (Fed. Cir. 2009). Moreover, a POSA would also expect the process to work using a mixture of glucose, maltose, and other short linear oligosaccharides that could be readily prepared by hydrolyzing starch. Ex. 1002, ¶ 173.

Motivations to use a feed composition containing mixtures described above (including starch hydrolysate) would include the desire to avoid expensive purified and isolated starting materials. Ex. 1002, ¶ 173. "If a person of ordinary skill in the art can implement a predictable variation, and would see the benefit of doing so, § 103 likely bars its patentability." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 401 (2007).

Claim [3]: A POSA would understand the disclosure of a "70 w/w % aqueous ***glucose*** solution" in Miyake Example 3 to refer to a "dextrose syrup," because POSAs and the '436 Patent use the terms "dextrose" and "glucose"

interchangeably, and a syrup is a concentrated solution of a sugar, such as a dextrose syrup or a solution of maltodextrin. *See supra* at VII.B.2; Ex. 1002, ¶ 39 (emphasis added); s*ee also* Ex. 1005 at 5:17; 6:67. The '436 Patent acknowledges that a 70% dextrose solution is a "syrup." Ex. 1001 at Fig. 5 ("70% Dextrose Syrup"); *see also id.* at 9:54-55 ("various corn syrups adjusted to approximately 70% DS [dry solids]"); 9:67; 10:63-65; 11:4; 14:60; 15:33. Ex. 1002, ¶ 154.

Claim [4]: The product of Example 3 includes "isomaltose" (32.6%), "isomaltotriose" (34.5%), and "isomaltotetraose" (19.6%), each of which is slowly digestible, and whose total concentration is more than 50% by weight on a dry solids basis. Ex. 1005 at 9:15-32; Ex. 1002, ¶ 156. The '436 Patent expressly teaches that isomaltose and non-linear oligomers with DP 4 (such as isomaltotetraose) are "slowly or incompletely digested by humans, if not totally indigestible." Ex. 1001 at 8:1-5. Those two oligosaccharides alone comprise more than 50% of the product. Although not included in the above cited passage from the '436 patent, isomaltotriose is also "slowly digestible" in humans. Ex. 1002, ¶¶ 156-57. Finally, the product of Example 3 would be slowly digestible under the Englyst assay. Ex. 1002, ¶ 158. And if it were not, then it would have been obvious to a POSA in 2006 how to modify the processes in Miyake so as to

achieve the required level of non-digestibility. Indeed, Example 4 teaches compositions with higher levels of higher non-linear oligosaccharides. Ex. 1005 at 9:63-66.

Claims [5], [6], [13]: A POSA would be motivated to contact the feed composition of Example 3 with glucoamylase (the catalyst) for about 20 to 100 hours in order to drive the reaction to completion and maximize the yield of oligosaccharides. Ex. 1002, ¶¶ 178-79. Based on Miyake's explicit disclosures of enzymolysis times that include 4 hours (Ex. 1005 at 7:68) and 48 hours (*id.* at 8:42), and a POSA's knowledge that enzymolysis times can vary based on many factors that include whether the enzyme is free or immobilized (*see id.* at 9:8-10), a POSA would be motivated to vary Example 3 using reaction times within the ranges specified in claims 5, 6, and 13. Ex. 1002, ¶¶ 178-79, 184; Ex. 1005 at 8:35-42. *See Boston Sci*, 554 F.3d at 991 ("[c]ombining two embodiments" from same patent). Moreover, a POSA would have a reasonable expectation of success in adjusting the reaction time because, as recognized by the Examiner during prosecution of the '436 Patent: "The time of contact with a catalyst . . . would have been obviously within the knowledge of the ordinary worker in the field." Ex. 1004 at 4. Dr. Demchenko agrees. Ex. 1002, ¶ 178.

Finally, the additional elements of [13] arising from its dependence on [7] are addressed in the following section.

Claims [7]-[9]: Miyake discloses using the enzyme "glucoamylase" as a catalyst to form a product with 4.2% glucose (*i.e.*, dextrose) residue. Ex. 1005 at 9:9-10; 9:29-32). The '436 Patent acknowledges that glucoamylase "accelerates the rate of cleavage of alpha 1-2, 1-3, 1-4, or 1-6 glucosyl bonds to form dextrose residues." Ex. 1001 at 3:31-36. Ex. 1002, ¶¶ 159-61.

Claim [10]: Because of the relatively high cost of enzymes, a POSA would be motivated to vary the amount of enzymes used for the process within the range in claim [10]. Such variations were routine and well within the POSA's knowledge. Ex. 1002, ¶ 180.

Claims [11]-[12]: Miyake first maintains the feed composition at 50ºC during contact with glucoamylase, and then, while they are still in contact, adds them to an ion-exchange column at a temperature of 75ºC. Ex. 1005 at 9:8-18. A POSA would recognize that during the feed composition's contact with the enzyme, it was maintained at "about 55–75ºC." Ex. 1002, ¶ 162.

Moreover, a POSA would be motivated to design a robust process that could work not only at 50ºC or 75ºC, but also at intermediate temperatures (such as 60ºC

or 65ºC). Ex. 1002, ¶ 181. As recognized by the Examiner, the "time of contact with a catalyst, as well as . . . temperature . . . would have been obviously within the knowledge of the ordinary worker in the field." Ex. 1004 at 4. Dr. Demchenko agrees. Ex. 1002, ¶ 182.

Claims [15]-[16]: Miyake discloses that after contacting the glucose solution with glucoamylase, the solution is acidified to pH 4.8. Ex. 1005 at 9:7-12. The acid acts as a co-catalyst, accelerating the cleavage and formation of glucosyl bonds, by providing protons for the enzymatic reaction. Ex. 1002, ¶ 163. The pH and type of acid would have been within the knowledge of the ordinary worker, and hydrochloric acid and sulfuric acid are both used in Miyake. *Id.,* ¶ 185; Ex. 1005 at 7:58, 9:38; Ex. 1004 at 4.

Claims [23]-[24]: A POSA would be motivated to concentrate the 70% glucose feed in Miyake (including to about 75%) to achieve a higher product yield. Applying Le Châtelier's Principle, a POSA would know that minimizing the water in the feed (and thus increasing the solids concentration) drives the reaction toward glycosylation (*i.e.*, formation of oligosaccharides) instead of hydrolysis (production of glucose). Ex. 1002, ¶ 186-87. Also, as the Examiner stated during

prosecution of the '436 Patent, "[T]he . . . feed concentrations would have been obviously within the knowledge of the ordinary worker . . . ." Ex. 1004 at 4.

Claims [25]-[27]: As discussed above regarding elements [1E]-[1F], Miyake discloses a product with a concentration of non-linear DP3 or higher oligosaccharides (isomaltotriose + isomaltotetraose) of at least 54.1% by weight on a dry solids basis. Ex. 1005 at 9:15-32; Ex. 1002, ¶¶ 164-66.

Claim [28]: As discussed above regarding elements [1E]-[1F], Miyake discloses a product with a concentration of non-linear oligosaccharides of at least 86.7% (isomaltose + isomaltotriose + isomaltotetraose)—more than twice the concentration of any linear oligosaccharides. Ex. 1002, ¶ 167; Ex. 1005 at 9:15-32.

Claim [29]: Example 3 contains 4.2% residual glucose (monosaccharide), a minor amount. Ex. 1005 at 9:28-31. Miyake discloses that the product "may be purified" with a "glucose-removing membrane filter" (a type of membrane filtration) or by "fractionation" (a type of chromatographic fractionation). *Id.* at 2:43-49. Ex. 1002, ¶ 168.

Claim [30]: Miyake contacts the solution with glucoamylase (an enzyme catalyst), and then incubates the mixture at pH 4.8. Ex. 1005 at 9:8-12. To

achieve a pH of 4.8 necessarily requires use of an acid. The acid activates the glucoamylase enzyme, and thus accelerates the rate of cleavage or formation of glycosidic bonds to form isomaltotriose and other oligosaccharides. Ex. 1002, ¶ 169.

Claim [32]: Miyake discloses hydrogenating the product composition using "catalytic hydrogenation" with a Raney nickel catalyst. Ex. 1005 at 2:29-42; *see also id.* 12:20-25; 12:44-52; 12:65-66; 13:16-20; Ex. 1002, ¶ 170.

B. Grounds 3-4: Duflot (Ex. 1006) as Primary Reference

U.S. Patent No. 5,424,418 ("Duflot") (Ex. 1006) issued on June 13, 1995, and qualifies as prior art to the '436 Patent under 35 U.S.C. § 102(b). Duflot was not considered by the Examiner during prosecution of the '436 Patent. Duflot discloses a two-catalyst process for preparing a non-linear oligosaccharide—in particular, a "soluble glucose polymer predominantly composed of 1→6 bonds, characterized by the fact that it possesses practically no reducing power and that its content of products of molecular weight less than or equal to 182 is extremely low." Ex. 1006 at 3:60-65; 13:6-23. Glucose and sorbitol have molecular weights less than or equal to 182. Ex. 1002, ¶ 201.

In Example 3, the glucose polymer (referred to as "Product D") is prepared by mixing dextrose and water, and then introducing sulfuric acid (catalyst # 1). The solution is then subjected to amyloglucosidase enzyme (catalyst # 2), followed by decoloration and hydrogenation. Ex. 1006 at 13:1-59.

Ground 3 of this petition asserts that Duflot anticipates claims 1, 3-9, 11, 13-17, 23-29, and 31-33. Ground 4 asserts that Duflot, in combination with Cleland, and/or the POSA's working knowledge, renders obvious claims 1-9, 11, 13-29, and 31-33. Because Cleland was published on September 16, 1952, it qualifies as prior art under 35 U.S.C. § 102(b) and may be combined with Duflot.

A POSA would be motivated to combine the two references because they are in the same art, and address similar aims—preparing dextrose polymers—using similar processes, with similar starting materials, concentrations, temperatures, and catalysts. For example, both references disclose heating a concentrated dextrose solution to similar temperatures, with a sulfuric acid catalyst. *Compare* Ex. 1006 at 13:1-11 *with* Ex. 1007 at 3:42-44; 4:43-52. Each produces non-crystallizing glucose polymers. *Compare* Ex. 1006 at 5:18, 6:9-12, 8:13, 3:45 *with* Ex. 1007 at 2:8-10; Title. Both disclose the production of dextrose polymers with minimal

residual dextrose. *Compare* Ex. 1006 at 13:30-33 *with* Ex. 1007 at 3:2-6; 3:20-25; *see also* Ex. 1002, ¶¶ 238-39.

1. Duflot discloses each element of claim 1

[1Pre]: Duflot discloses production of a soluble "glucose polymer predominantly composed of 1–6 bonds." Ex. 1006 at Abstract; 5:19-20; 8:13-14. The compound is prepared from dextrose and (as discussed below for [1E] and [1F]) is composed of between 8 and 15 dextrose units.

Elements [1A]-[1B]: Example 3 of Duflot discloses a feed with 500 kg of the monosaccharide dextrose and 25 liters of water. The solution is heated until the "dextrose dissolves completely." Ex. 1006 at 13:2-7. Because 25 liters of water weigh approximately 25 kilograms, the feed comprises 95% solids concentration by weight. Ex. 1002, ¶¶ 193-94.

Element [1C]: Duflot conducts the condensation reaction at "155ºC over 8 hours." Ex. 1006 at 13:8-10.

Element [1D]: Duflot uses acid and enzyme catalysts to prepare the polymer. After the dextrose is dissolved in water, Duflot contacts the feed composition with aqueous sulfuric acid. Ex. 1006 at 13:6-8. The acid acts as a "catalyst," accelerating the formation of 1–6 glucosyl bonds. *Id.* at 4:16-20.

Duflot contacts the mixture with amyloglucosidase, an enzyme that accelerates the formation or cleavage of glucosyl bonds. *Id.* at 13:20-23; Ex. 1002, ¶¶ 196-98.

Element [1E]: The reaction product is a "glucose polymer ***predominantly*** composed of 1–6 bonds." Ex. 1006 at Abstract; 4:16-20; 5:19-20; 6:9-10; 8:10-15; 17:21-25 (emphasis added). The bonds other than 1–6 bonds are "atypical 1–2, 1–3 bonds," and thus also non-linear. *Id*. at 1:22-24; Ex. 1002, ¶ 199. At a 99.8% concentration, the "glucose polymer" is the major product, with only "traces" of unreacted glucose and other materials. Ex. 1006 at 13:56-57; 14:15-26 (Product "D"). Accordingly, the concentration of the non-linear glucose polymer is greater than that of any linear oligosaccharide. Ex. 1002, ¶ 199.

Element [1F]: The weight-average molecular weight (Mw) of the glucose polymer of Example 3 ("product D") is 2,500 and the number-average molecular weight (Mn) is 1,300. Ex. 1006 at 13:66-14:8; 16:65-17:14. The poly-dispersity (ratio between Mw and Mn) is less than 2, which "demonstrates the size homogeneity of the molecules constituting these new products." Ex. 1006 at 17:15-18; Ex. 1002, ¶ 201. The number-average molecular weight Mn corresponds to a DP of 8. Ex. 1002, ¶¶ 200-01. Given the average DP of 8 and the low poly-dispersity, at least 20% by weight of the oligosaccharides have a DP of at

least 3. Indeed, significantly more than 50% will have a DP of at least 3. *Id.,* ¶ 200-02.

Duflot further recites that the components with molecular weight less than or equal to 182 (*e.g.*, glucose or sorbitol) are present at less than 0.50% by weight. Ex. 1006 at 4:3-6; *see also id.* at 18:13-22.

A POSA's knowledge would readily provide any elements of claim 1 that are deemed not sufficiently disclosed by Duflot.

2. Duflot anticipates or renders obvious, alone or in combination with Cleland and/or a POSA's knowledge, many dependent claims

Claim [2]: As explained above for Miyake [2], a POSA would have a reasonable expectation of success using a starting material that includes not only glucose, but also linear saccharide oligomers, and would be motivated to do so to be able to use less expensive starting materials. Ex. 1002, ¶¶ 243-44.

Claim [3]: Duflot's feed composition is a dextrose syrup with 95% solids concentration, as discussed for [1B]. Duflot consistently refers to its saccharide solutions as "syrups." *See*, *e.g.*, Ex. 1006 at 2:55-60; Ex. 1002, ¶¶ 204, 245. The dextrose "dissolves completely" and is mixed "with a stirrer." Ex. 1006 at 13:2-7.

Claim [4]: Duflot discloses that the soluble glucose polymer is "not very digestible." Ex. 1006 at 6:9-13; *see also id.* at 1:22-24; 17:9-14. As is set forth in the patent, and as explained by Dr. Demchenko, oligosaccharide compositions having a predominance of 1→6 bonds, such as Duflot's, are "slowly digestible." Ex. 1001 at 4:1-8; Ex. 1002, ¶ 205-07. The Duflot product would also be slowly digestible under the Englyst assay, a model for human digestion. Ex. 1002, ¶¶ 208-09. It would also have been obvious to a POSA in 2006 as to how to modify the process in Duflot so as to achieve the required level of non-digestibility. Ex. 1002, ¶ 246.

Claims [5]-[6]: Duflot discloses that the mixture is contacted with sulfuric acid (catalyst #1) "for over 8 hours" (Ex. 1006 at 13:10) and contacted with amyloglucosidase enzyme (catalyst #2) "for 60 hours." *Id.* at 13:23.

Claims [7]-[9], [11], [13]-[14]: Example 3 contacts the mixture with the amyloglucosidase at "at a temperature of 55ºC and at a pH of 5.5, for 60 hours." Ex. 1006 13:16-23. The process can alternatively be performed at "50ºC to 60ºC, duration of action from 30 to 72 hours, pH from 5.0 to 6.0." *Id.* at 6:30-33. The '436 Patent acknowledges that glucoamylase (another name for amyloglucosidase)

"accelerates the rate of cleavage of alpha 1-2, 1-3, 1-4, or 1-6 glucosyl bonds to form dextrose residues." Ex. 1001, 3:31-36; Ex. 1002, ¶¶ 212-17.

Regarding claim [8], contact with amyloglucosidase increased the concentration of dextrose residues, as indicated by the stated increase in "free glucose" and "anhydroglucose." *Compare* Ex. 1006 at 13:13-15 *with* 13:31-33.

Regarding claim [9], Duflot's amyloglucosidase is a "glucoamylase." Ex. 1002, ¶¶ 71, 214; Ex. 1019 (Handbook of Amylases) at 116.

Claims [15]-[16]: Duflot contacts the mixture with "sulfuric acid" prior to the amyloglucosidase step. Ex. 1006 at 13:1-15; Ex. 1002, ¶¶ 218-19.

Claims [17]: The pH can be calculated from the weight ratios of starting materials. Sulfuric acid is added to Duflot Example 3 so that the feed compositions have pH 3.25 to 3.60. Ex. 1002,, ¶¶ 220-22.

Claims [18]: Cleland discloses that "[v]arious acids may be employed to reduce the pH of the dextrose solution to a value of 0.5 to 4.5." Ex. 1007 at 3:42-48; *see also id*. at 4:6-10 ("pH of 1.5 to 2.5"); Ex. 1032 ¶ 251.

Claim [19]: The 95% solids concentration in Duflot is "about" 90%. In any event, this limitation would be obvious in view of Cleland's teachings of a range of concentrations. For example, Cleland states that the dextrose solution "may have a

reducing sugar content, calculated as dextrose on a dry substance basis, within the limits 70 to 100%." Ex. 1007 at 2:16-19; *see also id.* at 4:43-46; 4:55-56. Likewise, the starting material in one Cleland example is an aqueous solution of "refined '70' ***corn sugar*** (approx. 82% reducing sugar as dextrose on a dry basis) at a concentration of 45º Bè and pH of 1.5 to 2.5," which is heated "until the temperature has risen to 240º F." *Id.* at 4:6-13; *see also id*. at 2:16-23; 4:42-52 (solutions of at least 42º Bè) (emphasis added). A POSA would know that "Bè" (Baumè) is a measurement of specific gravity, such that a solution of 45º Bè is 45% denser than water and would have a total solids concentration of approximately 85%. Ex. 1002, ¶¶ 252-53; Ex. 1020 (Nutritive Sweeteners) at 33. Cleland discloses heating the solution between "200 to 300º F" (93-149º C), and undergoing "an acid reaction of 0.5 to 4.5 pH." Ex. 1006 at 4:37-51; *see also id.* at 2:16-31. 93º C is about 90º C. Ex. 1002, ¶ 254.

Claims [20]-[22] Duflot discloses a feed composition with a solids concentration of 95%, which is at least about 80%. *See above*, element [1B]. Likewise, Cleland discloses a feed composition with 75-80% solids concentration (*see supra* [19]). Cleland discloses that "[v]arious acids may be employed to reduce the pH of the dextrose solution to a value of 0.5 to 4.5. Hydrochloric acid

is preferred but sulfuric acid, phosphoric acid, . . . or any acid capable of reducing the pH of the solution to the desired amount may be employed." Ex. 1007 at 3:42-48; Ex. 1002, ¶¶ 247-48, 61. A POSA would also expect combining hydrochloric acid and phosphoric acid to work and would modify the choice of acids to develop the most effective process. Ex. 1002, ¶ 261.

Duflot maintains the acid-catalyzed reaction at 155 ºC for over 8 hours, which is "about 4-24 hours." Ex. 1006 at 13:1-11. A POSA would understand that increasing the temperature could allow for a shorter reaction or maintenance time, and would be motivated to try various combinations of temperatures and times within claims 20-22, and expect them to be successful. Ex. 1002, ¶ 260.

Claim [23]: The solids concentration of the feed composition is 95% by weight (*supra* Element [1B]).

Claim [24]: The solids concentration of the feed composition is 95% by weight (*supra* Element [1B]), and thus "about 75-90%"—or it would have been obvious to a POSA to use 90% rather than 95%. (*supra*, Claim [19]). Ex. 1002, ¶ 262.

Claims [25]-[28]: As discussed above with respect to [1E] and [1F], at a concentration of 99.8%, the "glucose polymer" is the majority reaction product,

and is non-linear. Ex. 1006 at 13:56-57; 14:15-26 (product "D"). At 99.8%, the amount of non-linear glucose polymer is more than twice any linear saccharide oligomer or other component. Further, the average DP of the glucose polymer is 8 with a small polydispersity, as discussed above for [1F], and the amount of non-linear glucose polymer with a DP of at least 3 is higher than 25%, 30%, or 50%. Ex. 1002, ¶¶ 225-28.

Claim [29]: The mixture contains residual glucose (8.5% free glucose and 0.9% anhydroglucose) after contact with amyloglucosidase. Ex. 1006 at 13:30-33. The product composition was then "subjected . . . to a molecular sieving stage, especially on membranes or by chromatography on absorbent materials, so as to remove the molecules of molecular mass less th[a]n or equal to 182." *Id*. at 5:17-24; *see also id.* at 6:63-64 ("molecular sieving, preferably performed by chromatographic fractionation"); Ex. 1002, ¶ 229.

Claim [31]: The feed composition is first contacted with sulfuric acid (catalyst # 1), and then contacted with amyloglucosidase enzyme (catalyst # 2). Ex. 1006 at 13:6-23. Both catalysts accelerate the rate of cleavage or formation of glycosidic (glycosyl) bonds. Ex. 1002, ¶¶ 230.

Claim [32]: The mixture contains residual glucose (8.5% free glucose and 0.9% anhydroglucose) after contact with amyloglucosidase. Ex. 1006 at 13:30-33. The product composition was then "subjected to a hydrogenation stage." Ex. 1006 at 5:17-24; *see also id.* at 13:33-34 ("hydrogenation"); Ex. 1002, ¶ 231.

Claim [33]: The Duflot product composition is "decolorized by hydrogenation." Ex. 1006 at 5:30-40. This decolorization can be accomplished, for example, by the "the treatment over activated charcoal" that is part of the hydrogenation process. *Id*. at 6:48-50; Ex. 1002, ¶ 232. The hydrogenation step taught in Duflot does not alter the DE of the product. Ex. 1002, ¶ 233.

C. Grounds 5-7: Shah (Ex. 1008) as Primary Reference

WO 98/41545 ("Shah") (Ex. 1008) received an international publication date of September 24, 1998, and qualifies as prior art to the '436 Patent under 35 U.S.C. § 102(b). Shah discloses a process for using acid catalysts to prepare food-grade glucose polysaccharides (polydextrose) from sugars or hydrolyzed starch, by reacting "maltose, glucose, or other simple sugar," with "a polyol such as sorbitol" and "in the presence of a sufficient amount of one or more mineral acid catalysts." Ex. 1008 at 5:13-21. The polydextrose product is highly branched (*i.e.*, nonlinear) and has a lower calorie content. *Id.* at 1:21-24, 2:5-9. Example 10 uses a

phosphoric acid catalyst, and Example 11 uses a combination of citric acid and hydrochloric acid. *Id.* at 21:27-31; 22:27-31.

Ground 5 of this petition asserts that two embodiments of Shah—the first row of Example 10 ("Embodiment A"), and the fifth row of Example 11 ("Embodiment B")—anticipate claims 1-4, 15-18, 23-29, and 31-32 of the '436 Patent.

Embodiment A

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Dextrose source	Sorbitol source	Weight percent phosphoric acid	Reaction time, min.	Weight percent residual glucose	APHA color
Cerelose	ICI Liquid	0.21	3	3.4	200

Embodiment B

WO 98/41545 PCT/US98/05468

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Glucose source	Sorbitol source	Weight percent HCl	Reaction time, min.	Weight percent residual glucose	APHA color
Clearsweet 95	ADM granular	0.0013	17	3.0	150

Ground 6 asserts that claims 1-4, 15-18, 23-29, and 31-32 are obvious in view of Shah in combination with the POSA's knowledge, and/or S.A.S. Craig *et al.*, "Chapter 18: Polydextrose as Soluble Fiber and Complex Carbohydrate," COMPLEX CARBOHYDRATES IN FOODS (ed. Susan Sungsoo Cho et al.) (Marcel Dekker, Inc.: 1999) ("Craig") (Ex. 1009). Craig was published in 1999

and qualifies as prior art under 35 U.S.C. § 102(b). *See* Ex. 1021 (Library of Congress Listing); Ex. 1002, ¶ 302. Craig provides additional teachings regarding polydextrose—its non-linearity with a majority of species having DP > 10, and its non-digestibility. A POSA would be motivated to combine Shah and Craig because Shah teaches processes to manufacture polydextrose, and Craig provides complementary information about the structure of, and applications for, the polydextrose made according to Shah. Ex. 1002, ¶ 305. Both references stem from Cultor Food Science, and both name Stuart Andrew Shaw (S.A.S.) Craig as an author/inventor. *Id*.

Ground 7 of this petition asserts that Shah, in combination with Craig and Cleland, and/or a POSA's knowledge, would render obvious claims 1-4, 15-29, and 31-32 of the '436 Patent. A POSA would be motivated to combine Shah/Craig with Cleland because all three references disclose polymerizing dextrose using similar processes to form products with similar properties. Like Shah and Craig, Cleland discloses using an acid catalyst with a heated dextrose solution to form a polymer. Ex. 1007 at 2:8-11, 2:40-46; *see also id.* at 1:1-2; 1:9-12. Shah and Cleland both heat the mixture to about 150ºC. *Compare* Ex. 1007 at 4:47-49 (300ºF) *with* Ex. 1008 at 21:36-37, 22:36-37 (302ºF). Both use feed compositions

with similar solids concentrations. Ex. 1002, ¶ 319-22. And both produce water-soluble products. *Compare* Ex. 1008 at 11:2-4 *with* Ex. 1007 at 2:8-10; Title.

1. Shah discloses each element of claim 1, alone or in combination with Craig

[1Pre]: Shah discloses the preparation of polydextrose. As discussed in element [1F], the average DP of the polydextrose is at least 6, and thus most molecules in a polydextrose composition are "saccharide oligomers." Ex. 1002, ¶ 268.

Elements [1A]-[1B]: Embodiments A and B each disclose feed compositions with total solids concentrations of at least about 70% on a dry solids basis. Each embodiment uses a 70% aqueous solution of dextrose, and then adds either a 70% sorbitol solution (Embodiment A) or solid sorbitol (Embodiment B). Ex. 1008 at 22:1-24, 23:1-29. The precise solids concentrations for the aqueous feed compositions may be calculated from the specified "89:10 ratio." *Id.* at 21:35, 22:34. As shown in Ex. 1002, ¶¶ 268-71, they are 70.04% and 72.39 % for Embodiments A and B, respectively:

Component of Feed Composition	**Embodiment A (Ex. 10, 1st Row)**	**Embodiment B (Ex. 11, 5th Row)**
Dextrose (anhydrous)	62.83%	64.43%
Sorbitol (anhydrous)	7.06%	7.24%
Phosphoric Acid	0.148%	N/A
Hydrochloric Acid	N/A	0.0019%
Citric Acid	N/A	0.72%
Water	29.96%	27.61%
Total Solids Concentration	**70.04%**	**72.39%**

Element [1C]: Embodiment A heats the feed to 150-160ºC. Embodiment B heats the feed to 150-166ºC. Ex. 1008 at 21:36-37; 22:36-37.

Element [1D]: Shah discloses contacting the feed composition with an acid catalyst to accelerate the formation of glucosyl bonds for a time sufficient to form the polydextrose. Embodiment A uses phosphoric acid, and Embodiment B uses a combination of hydrochloric acid and citric acid. Ex. 1008 at 21:35-37, 22:35-37. Shah refers to each of the above components as a "catalyst." *Id.* at 6:2-7; 9:1-3.

Element [1E]: The product composition is a polydextrose that is a non-linear saccharide oligomer. The polydextrose is "highly branched" and "is composed almost entirely of randomly cross-linked glucose polymers ***with all types of glucosidic bonds, the 1-6 bond predominating***, and it contains some sorbitol groups." Ex. 1008 at 2:5; 5:14; 11:4-8 (emphasis added). Polydextrose is

the majority product in that the polymerization reaction proceeds until it is "complete," achieving "at least 96% polymerization" with only "small amounts of residual starting materials and their reaction products." *Id.* at 10:21-24; 11:6-8; 15:6-7; *see also id.* at 14:1-4; 15:16-17; 22:1-23:15. Accordingly, the concentration of polydextrose is higher than that of any unnamed linear saccharide oligomer or other component. Ex. 1002, ¶ 274.

The disclosure of Shah may be combined with that of Craig, which discloses that the polydextrose product—which was prepared using similar processes to those in the Shah patent—has "random polymerization and branching [that] yields various types of glucosidic bonds in the structure (α-1,6 bonds predominate)." Ex. 1009 at 230. Craig provides a representative structure, confirming that the polydextrose is "non-linear" with predominantly α-1,6 bonds. Ex. 1009 at 230. In the figure below, Ex. 1002, ¶ 308, Dr. Demchenko identifies the non-linear (alpha-1→6, 1→2, and 1→3) linkages depicted in the Craig figure:

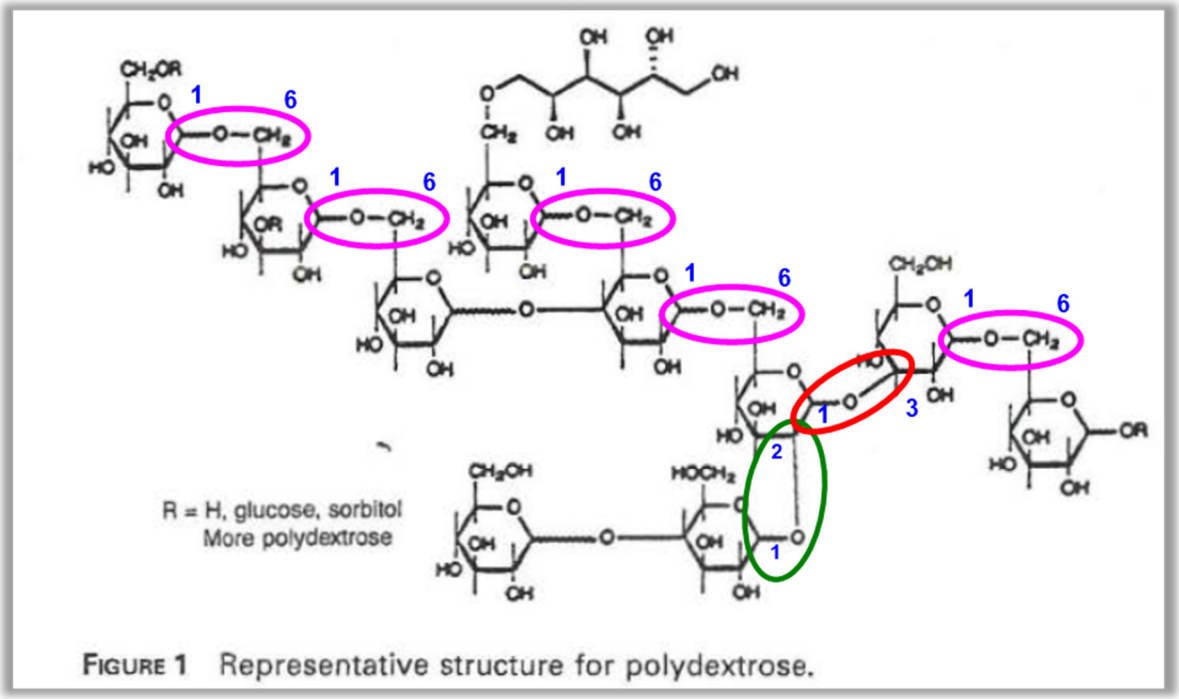

FIGURE 1 Representative structure for polydextrose.

Element 1[F]: Shah discloses that commercially available polydextrose typically has an average "molecular weight of from about 1,000 to about 3,000," and that Shah's "invention can be utilized to prepare like materials, as well as polysaccharides with average molecular weights above and below this range." Ex. 1008 at 13:30-14:4. From these average molecular weights, the average DP of Shah's polydextrose can be calculated as between approximately 6 and 19. Ex. 1002, ¶¶ 275-77.

Shah may also be combined with Craig, which discloses that polydextrose is digestion "resistant," and the "average DP is 12." Ex. 1009 at 232; *see also id*. at

231 at Fig. 2. Cleland also provides additional teachings about the feedstock. Ex. 1002, ¶¶ 325-26, 330.

2. Shah anticipates, and—in combination with Craig and/or a POSA's knowledge, or in combination with Cleland and Craig—renders obvious many dependent claims

Each of the claims below incorporates the limitations from independent claim [1], which, as discussed above, Shah discloses.

Claim [2]: The feedstock in Embodiment B uses "Clearsweet-95," the tradename of "70% solution of 95 DE dextrose, Cargill." Ex. 1008 at 23:16, 23:26; Ex. 1002, ¶ 279. The Clearsweet® 95 product manufactured by Cargill contained, on a dry basis, 95.0% dextrose, and linear oligosaccharides (3.0% maltose and 0.5% maltotriose). Ex. 1002, ¶ 279; Ex. 1022 (Cargill datasheet); Ex. 1023 (internet archive exhibit showing date of availability). Shah's invention works "by reacting a saccharide such as maltose, glucose, or other simple sugar." Ex. 1008 at 5:14-15; 7:26-8:3; 10:31-32; *see also* Ex. 1002, ¶ 330.

Claim [3]: The 70% dextrose solutions used in Embodiments A and B are each a dextrose "syrup." Ex. 1002, ¶ 280. The '436 Patent confirms that a 70% dextrose solution is a syrup. *See* discussion of Miyake element [3]. Further, the

Cargill datasheet confirms that the Clearsweet 95 used in Embodiment B is a "95% ***Dextrose*** Corn Syrup." Ex. 1022 (emphasis added).

Shah can be combined with Cleland's examples, which use dense solutions that are syrups (*e.g.*, having specific gravity of 45º Bè) and "corn syrups." Ex. 1002, ¶ 331.

Claim [4]: As discussed above regarding [1E] and [1F], the average DP of the polydextrose is between approximately 6 and 19; the product is "***highly branched***" and "is composed ***almost entirely*** of randomly cross-linked glucose polymers with all types of glucosidic bonds, ***the 1-6 bond predominating***." Ex. 1008 at 2:5; 5:14; 11:4-8; 13:30-14:4 (emphasis added). As taught in the '436 Patent, oligosaccharides having these structural features are "slowly digestible." Ex. 1001 at 4:1-8; 8:1-4 ("branched oligomers having a degree of polymerization of four or greater" are slowly digestible); Ex. 1002, ¶¶ 100-111. Moreover, Craig specifically teaches that polydextrose is a resistant oligosaccharide ("RO"), which is "resistant to hydrolysis by human alimentary enzymes and reach the lower intestine." Ex. 1009 at 229; *see also* Ex. 1024 ("Lauridsen") ¶ 0020; Ex. 1002, ¶¶ 102, 310. Accordingly, as evidenced by the structural features of the polydextrose, and the statement of its digestive resistance in Craig, more than 50%

of the polydextrose composition disclosed in Shah is "slowly digestible." Ex. 1002, ¶¶ 294-97, 310. The polydextrose composition disclosed in Shah would be slowly digestible under the Englyst assay, a model for human digestion. Ex. 1002, ¶¶ 284-85. It would also have been obvious to a POSA in 2006 as to how to modify the process in Shah so as to achieve the required level of non-digestibility. Ex. 1002, ¶¶ 310-12.

Claims [15]-[16]: Shah discloses a wide variety of catalysts, including hydrochloric, sulfuric, phosphoric, and other acids. Ex. 1008 at 5:27-31. Embodiment A discloses phosphoric acid, and Embodiment B discloses a combination of hydrochloric and citric acids as the catalysts. *Id*. at 21:35-37; 22:35-37.

Shah may also be combined with Cleland's disclosures of acid catalysts, including hydrochloric, sulfuric, or phosphoric acid. Ex. 1007 at 3:42-48.

Claims [17]-[18]: Using the information provided in Shah Embodiments A and B, including the amount of acid that is added, the pH of the feed composition can be calculated to be about 2.1. Dr. Demchenko's Declaration presents this straightforward calculation. Ex. 1002, ¶¶ 288-91.

Shah may also be combined with Cleland, which discloses acidifying the solution to a "pH of 1.5 to 2.5." Ex. 1007 at 4:6-10 (emphasis added); see also id. at 4:65-72 (disclosing pH range of 0.5 to 2.0). Cleland also discloses that "[v]arious acids may be employed to reduce the pH of the dextrose solution to a value of 0.5 to 4.5." Ex. 1007 at 3:42-48.

Claims [19]-[21]: Section XII.B.2 (Ground 4 at Claims [19]-[21]) *supra*, discusses where the elements in dependent claims 19-21 (apart from those elements in independent claim 1) are disclosed in Cleland. That section is incorporated herein.

Claims [22]: Cleland also discloses that "[v]arious acids may be employed" including hydrochloric, sulfuric, or phosphoric acid. Ex. 1007 at 3:42-48.

Claims [23]-[24]: Shah's Embodiment B discloses a feed composition that is 72.47% solids by weight, which is "at least about 75% solids by weight." *See* above discussion for element [1B]; Ex. 1002, ¶¶ 292-93. In any event, it would have been obvious for a POSA to vary the solids concentration of Embodiment B slightly, including increasing it slightly to about 75% (claim 23) and therefore about 75-90% (claim 24). Ex. 1002, ¶¶ 350-51.

As shown above for claim 19, Cleland discloses a solution with a specific gravity of 45º Bè, which corresponds to a solids concentration of around 85%.

Claims [25]-[28]: The reaction product for the Shah embodiments is a polydextrose, which is a non-linear saccharide oligomer with DP of at least 6. Because Shah proceeds until reaction "is complete" and achieves "at least 96% polymerization," the concentration of polydextrose is greater than 25%, 30%, and 50%, and more than twice the concentration of any unnamed linear saccharide oligomer or other component. *See* above discussion regarding elements [1E] and [1F]; Ex. 1002, ¶¶ 294-97. Craig also teaches that the average DP is 12. Ex. 1002, ¶¶ 313-15.

Claims [29], [32]: As discussed above with respect to [1E], Shah Embodiments A and B each disclose less than 4% residual glucose. Ex. 1008 at 22:1-5; 23:1-17; *see also id.* at 14:2-4. The polydextrose product is "further purified by ion exchange, size exclusion ***chromatography***, ***membrane filtration***, enzyme treatment and/or carbon treatment, and/or modified ***by hydrogenation***." *Id.* at 6:30-32 (emphasis added); *see also id.* at 10:3-5; 11:21-31.

Claim [31]: As discussed with respect to claim 1, Shah contacts the feed composition with acid catalysts to prepare the polydextrose. Shah also discloses

contacting the polydextrose "with enzymes to improve color, color stability, taste, viscosity, stability, and the like . . . to cleave bonds found in the unwanted products of side reactions formed during the course of the polymerization reaction, or to remove unwanted low molecular weight products," such as glucose. Ex. 1008 at 13:13-20.

D. Ground 8: Duan (Ex. 1010) as Primary Reference

U.S. Patent No. 7,638,151 ("Duan") (Ex. 1010), was filed March 10, 2004 and published on February 10, 2005. Duan claims ultimate priority to a provisional application filed March 10, 2003, and thus qualifies as prior art to the '436 Patent under 35 U.S.C. § 102(e). Duan discloses the use of enzymes to prepare "isomalto-oligosaccharides ('IMOs')," which are "mixed linkage oligosaccharides, having mixtures of 1,4 alpha and/or 1,6 alpha glucosidic linkages" for use in food products, such as dietary fiber. Ex. 1010 at 1:20-58.

Duan prepares the IMOs using a two-stage enzymatic process. *Id.* at 33:26-37. First, Duan forms an aqueous, maltose-rich feed composition by hydrolyzing a slurry of cereal (*e.g.*, wheat or rye) using enzymes. Second, Duan forms IMOs by glycosylating (condensing) the maltose-rich feed composition using a second set of enzymes (transglucosidase). *See generally id.* at 4:45-50; 11:1-12; 29:9-30:1; Fig.

2. The two-stage process in Duan is similar to a two-stage process of the '436 Patent, in which maltodextrin is hydrolyzed "to form the feed composition," which is then condensed to form oligosaccharides. Ex. 1001 at 3:16-23; 22:11-14; Ex. 1002, ¶¶ 353-54. Ground 8 asserts that Duan renders obvious claims 1 - 8, 11 - 16, 23 - 31, 34 – 36.

1. Duan renders obvious claims 1 and many dependant claims

The discussion below focuses on the "rye flour" embodiment of Example 6 (Table 7). Ex. 1010 at 29:10-30:30; Ex. 1002, ¶ 355.

a) Duan renders obvious claim 1

Except for element [1B], Duan expressly discloses each element of claim 1 in a single embodiment. As discussed below, element [1B] would have been obvious to a POSA in view of the disclosure of Duan.

[1Pre]: The isomalto-oligosaccharides (IMOs) "are mixed linkage oligosaccharides, having mixtures of 1,4 alpha and/or 1,6 alpha glucosidic linkages," and containing "a substantial amount of branched oligosaccharides" as summarized in "Table 7" in Duan. Ex. 1010 at 1:21-28; *see also id.* at 7:1-8.

Duan discloses the percentage of "Branch G3+" in its compositions, which refers to "branched" oligosaccharides with a degree of polymerization greater than 3. See Ex. 1010 at 8:10-12; 1:24-28; col. 28 (last line); Ex. 1002, ¶ 358.

Element [1A]: An aqueous maltose-rich feed composition is prepared by hydrolyzing a 28% slurry of rye flour, hydrolyzing the starch using alpha-amylase and beta-amylase, and incubating the slurry for 4.5 hours. Ex. 1010 at 29:9-30:7. The maltose-rich feed composition contains linear saccharide oligomers (maltose and maltotriose) and a monosaccharide (glucose). *Id.* at 12:1-13; 13:60-14:9; 14:50-57; Ex. 1002, ¶¶ 359-60.

Element [1B]: Duan teaches that hydrolyzing a starch slurry (as described above) "generally results in syrups containing ***greater than 50%*** maltose," which encompasses feed compositions containing greater than 70% solids, as required by the claim. Ex. 1010 at 29:10-12 (emphasis added). Duan states only a lower limit ("generally greater than 50%"), and criticizes prior-art hydrolysis processes in which "the syrup produced by such process resulted in only 55% maltose." *Id.* at 3:44-51; *see also* 3:35-41 (discussing conventional process to increase the maltose content above 62%).

Such criticisms, as well as a desire to obtain increased yields, would motivate a POSA to increase the solids concentrations to at least 70%. Duan teaches how to do just that: (i) increasing the concentration of the starch-containing slurry up to 90% dissolved solids (Ex. 1010 at 13:35-47); and (ii)

adding a debranching enzyme to hydrolyze the starch into maltose. *Id.* at 19:25-40. A POSA would know that as the hydrolysis of the starch slurry proceeds, one water molecule is consumed for each glycosidic linkage that is broken. As water is consumed, the solids concentration increases. By starting with a slurry containing 90% solids, the post-hydrolysis solids concentration will be at least 90%. Ex. 1002, ¶¶ 361-63.

Elements [1C]-[1D]: The feed composition (*i.e.*, the maltose-rich syrup) is contacted with the enzyme catalyst "transglucosidase" for 48 hours at 60ºC to form the non-linear oligosaccharides summarized in Table 7. Ex. 1010 at 30:8-30; 2:18-33; 18:25-41. Duan and the '436 Patent use the same brand of transglucosidase—"Transglucosidase L-500 (supplied by Genencor)." Ex. 1001 at 9:51; Ex. 1010 at 30:10; Ex. 1002, ¶¶ 364-65.

Elements [1E]: Table 7 of Duan lists the components of the product composition for the rye flour embodiment, on a dry solids basis. Ex. 1010 at 8:31-33. It consists of 64.22% non-linear oligosaccharides (isomaltose, panose, isomaltotriose, and Branch G3+), 13.60% linear oligosaccharides (maltose, maltotriose), and further specifies that 53.07% are non-linear DP3 and higher

(panose, isomaltotriose, and Branch G3+). *See* Ex. 1002, ¶¶ 366-70 (with similar calculation using "IMO").

The rye flour embodiment of Example 6 thus discloses a product with a higher concentration of non-linear saccharide oligomers (64.22%) than linear saccharide oligomers (13.60%). *Id*.

Element [1F]: Referring to the above discussion of [1E], the rye flour embodiment discloses non-linear saccharide oligomers with a DP of at least three in a concentration of 53.07%, which is greater than 20%. Ex. 1002, ¶ 371; Ex. 1010 at 8:31-33.

b) Duan renders obvious dependent claims

Each claim below incorporates the limitations from independent claim 1, which are discussed above.

The limitations added by the dependent claims pertain to routine adjustments of the processing conditions, such as concentrations, reaction time, pH, and temperature. Ex. 1002, ¶ 374. Such adjustments were well within the purview of a POSA. *Supra*, at IX.A.

Claim [2]: Duan forms the maltose-rich feed composition containing glucose (monosaccharide) and maltose (linear saccharide oligomer) by hydrolyzing

rye flour with native beta-amylase and with added alpha-amylase. Ex. 1010 at 29:10-30:5. The alpha-amylase "yield[s] a mixture of glucose, maltose, maltotriose and higher sugars," and the beta-amylase (present in the rye cereal) "yield[s] maltose." *Id.* at 12:1-8; *see also id.* at 14:1-3; Ex. 1002, ¶ 375.

Claim [3]: A POSA would have been motivated to use a "corn syrup" to prepare the isomalto-oligosaccharides. Duan teaches that "maltose ***syrup***" is used to produce "isomalto-oligosaccharides" Ex. 1010 at 5:10-39; 10:25-28; 29:10-12 (emphasis added), and that the maltose can be obtained enzymatically (*id.* at 6:45-48) from a wide variety of plants, particularly grains. *Id.* at 5:65-6:42. Immediately after defining "rye" (which is the embodiment discussed above regarding claim [1]), Duan defines "corn" as an exemplary grain that can be used with the invention. *Id.* at 6:12-17.

Claim [4]: The isomalto-oligosaccharides' (IMOs) compositions disclosed in Duan are asserted to be useful for prebiotics, which Duan notes "are defined as ***non-digestible*** substances (*e.g.*, dietary fiber)." *Id.* at 1:46-58 (emphasis added); *see also id.* at 13:1-7. The non-digestibility of such substances is attributable to their chemical structure. Indeed, 64.22% by weight on a dry solids basis of Duan's rye flour Example 6 (Table 7) consists of isomaltose, panose, and branch G3+

oligosaccharides—which the '436 patent expressly teaches are "slowly digestible" non-linear oligosaccharides. Ex. 1002, ¶ 379; Ex. 1001 at 8:1-5. Accordingly, more than 50% of the dry weight of the IMOs' compositions are "slowly digestible." Ex. 1002, ¶¶ 377-80. Finally, the Duan IMOs' compositions would be slowly digestible under the Englyst assay. *Id.,* ¶ 381-82. And if they were not, then it would been obvious to a POSA in 2006 as to how to modify the process in Duan so as to achieve the required level of non-digestibility. *Id.,* ¶¶ 383-85.

Claims [5]-[7], [11]-[13]: Duan discloses each of the limitations added by these claims. The maltose-rich feed composition is contacted with an enzyme catalyst (transglucosidase) and "then incubated at 60ºC water bath for 48 hours" to form the IMOs. Ex. 1010 at 30:10-12; Ex. 1002, ¶¶ 386-88, 390-92.

Claim [8]: The enzymes disclosed in Duan accelerate the rates of cleavage of the linkages in maltose to form oligosaccharides and dextrose residues. The rye flour embodiment in Example 6 starts with a maltose-rich syrup (*e.g.*, 50% or more maltose), but ends up with a syrup containing only 22.18% glucose (dextrose) residues. Ex. 1002, ¶ 389.

Claim [14]: The rye flour embodiment involves contacting the feed composition with the enzyme for 48 hours, Ex. 1010 at 30:7-14, which is "about

50–100 hours." Moreover, it would have been obvious to use a longer reaction time so as to drive the polymerization reaction to completion to increase the yield. Indeed, Duan discloses other embodiments (*e.g.*, Example 5 / Table 6) with a reaction time of 72 hours. Ex. 1002, ¶ 393.

Claim [15]-[16]: Duan discloses that as part of the transglucosidase step, the "pH of the incubated samples was then adjusted to pH 4.5 using 6 N H_2SO_4 and 1.25 kg of transglucosidase (*e.g.*, a transglucosidase sold under the tradename TRANSGLUCOSIDASE L-500 by Genencor International) . . . was added." Ex. 1010 at 30:7-12. The solution of H_2SO_4 is "sulfuric acid," which acts as a co-catalyst, accelerating the cleavage and formation of glucosyl bonds, by providing protons for the enzymatic reaction. Ex. 1002, ¶¶ 98-99, 394-95. Also, as the Examiner stated during prosecution of the '436 Patent: "The type of catalyst whether ***enzymatic, acid or combination***, temperature, ***pH*** and feed concentrations would have been obviously within the knowledge of the ordinary worker . . . ." Ex. 1004 at 4 (emphasis added). Dr. Demchenko agrees. Ex. 1002, ¶ 374.

Claims [23]-[24]: A POSA would have been motivated to increase the solids concentration in the maltose-rich feed composition, including to at least

about 75%, for the reasons described above regarding claim element [1B]. Ex. 1002, ¶¶ 361-63.

Claims [25]-[28]: As further described above with respect to elements [1E] and [1F], the rye flour embodiment of Example 6 discloses a product with non-linear saccharide oligomers of DP 3 or higher in a concentration of 53.07% by weight on a dry solids basis. The total non-linear saccharide concentration (64.22%) is more than twice the total linear concentration (13.6%). Ex. 1002, ¶¶ 398-401.

Claim [29]: Duan discloses residual monosaccharides (glucose) with a concentration of 22.18%. Ex. 1010 at 30 tbl. 7. This concentration is a "minor" amount, as it is less than 50% by weight on a dry solids basis. The residual monosaccharides can be removed, and the "syrup can be enriched in isomalto-oligosaccharides by a ***chromatographic*** technique or by nano- or ultra-***filtration***." *Id.* at 23:5-8; *see also id.* at 20:37-53; Ex. 1002, ¶ 402 (emphasis added).

Claims [30]-[31]: The cereal starch is contacted with alpha-amylase (***enzyme***) to accelerate cleavage of the alpha-(1→4) bonds to form a maltose-rich syrup containing glucose, maltose, and other sugars. Ex. 1010 at 29:12-30:2; 12:1-8; 14:1-3. The maltose-rich syrup (post-hydrolysis) is then contacted with sulfuric

acid—"adjusted to pH 4.5 using 6 N H_2SO_4"—and then subsequently contacted with transglucosidase (another ***enzyme***). *Id.* at 30:7-12. The combined action of the enzyme/acid/enzyme hydrolyzes the starch into a maltose-rich syrup (accelerating cleavage rate of 1→4 bonds) and then condenses the syrup to form the oligosaccharides disclosed in Table 7 (accelerating formation of 1→6 bonds). Ex. 1002, ¶¶ 403-04.

Claims [34]-[35]: Duan teaches hydrolyzing a slurry of rye flour using alpha-amylase and beta-amylase to form a hydrolyzed saccharide solution (a maltose-rich syrup), as discussed above regarding element [1B]. The hydrolysis proceeds by consuming one water molecule for every linkage in the rye flour, thus concentrating the hydrolyzed saccharide solution as the reaction proceeds (*i.e.*, the concentrating and contacting with amylase catalysts occur simultaneously). Ex. 1002, ¶ 405-07. A POSA would be motivated to try maltodextrin (in place of rye flour), and have a reasonable likelihood of success, because maltodextrin has a similar structure to starch, the main component of the rye flour. Both are saccharide oligomers with primarily alpha-(1→4) glucosidic bonds. *Id.,* ¶ 406. Accordingly, a POSA would know that the enzyme action on maltodextrin and

starch would be similar, and that these compounds can be used interchangeably. *Id.*

Claim [36]: Duan also discloses concentrating prior to contacting the feed composition with the transglucosidase. Prior to contacting with transglucosidase, Duan incubates the mixture at 60ºC for 4.5 hours. Ex. 1010 at 30:5-7. A POSA would know that at 60ºC, some of the water would evaporate, making the solution more concentrated prior to the addition of the transglucosidase. *Id*.; Ex. 1002, ¶ 408.

XIII. CONCLUSION

Petitioner respectfully requests that this petition be granted, that *inter partes* review be instituted, and that all claims of the ’436 Patent be found unpatentable and cancelled.

XIV. CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24, the undersigned attorney for the Petitioner declares that the argument section of this Petition (Sections I, III–XIII) has a total

of 13,958 words, according to the word count tool in Microsoft Word™ and hand count of the figures.

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Respectfully Submitted,

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CERTIFICATE OF SERVICE

The undersigned certifies service pursuant to 37 C.F.R. §§ 42.6(e) and 42.105(a), (b) on the Patent Owner via USPS Priority Mail of a copy of this Petition for *Inter Partes* Review and supporting materials to the Patent Owner:

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