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(54) Title: GLUCAN FIBER COMPOSITIONS FOR USE IN LAUNDRY CARE AND FABRIC CARE

(57) Abstract: An enzymatically produced α -glucan oligomer/polymer compositions is provided. The enzymatically produced α -glucan oligomer/polymers can be derivatized into α -glucan ether compounds. The α -glucan oligomers/polymers and the corresponding α -glucan ethers are cellulose and/or protease resistant, making them suitable for use in fabric care and laundry care applications. Methods for the production and use of the present compositions are also provided.



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TITLEGLUCAN FIBER COMPOSITIONS FOR USE IN LAUNDRY CARE AND
FABRIC CARE5 CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of priority of United States Provisional Application No. 62/255,217, filed on November 13, 2015, the entire disclosure of which is hereby incorporated by reference.

INCORPORATION BY REFERENCE OF THE SEQUENCE10 LISTING

The official copy of the sequence listing is submitted electronically via EFS-Web as an ASCII formatted sequence listing with a file named 20161104_CL6278WOPCT_SequenceListing_ST25.txt created on November 2, 2016 and having a size of 91,265 bytes and is filed
15 concurrently with the specification. The sequence listing contained in this ASCII-formatted document is part of the specification and is filed herein incorporated by reference herein in its entirety.

FIELD OF DISCLOSURE

This disclosure relates to oligosaccharides, polysaccharides, and
20 derivatives thereof. Specially, the disclosure pertains to certain α -glucan polymers, derivatives of these α -glucans such as α -glucan ethers, and their use in fabric care and laundry care applications.

BACKGROUND

Driven by a desire to find new structural polysaccharides using
25 enzymatic syntheses or genetic engineering of microorganisms, researchers have discovered oligosaccharides and polysaccharides that are biodegradable and can be made economically from renewably sourced feedstocks.

Various saccharide oligomer compositions have been reported in
30 the art. For example, U.S. Patent 6,486,314 discloses an α -glucan comprising at least 20, up to about 100,000 α -anhydroglucose units, 38-48% of which are 4-linked anhydroglucose units, 17-28% are 6-linked anhydroglucose units, and 7-20% are 4,6-linked anhydroglucose units and/or gluco-oligosaccharides containing at least two 4-linked

anhydroglucose units, at least one 6-linked anhydroglucose unit and at least one 4,6-linked anhydroglucose unit. U.S. Patent Appl. Pub. No. 2010-0284972A1 discloses a composition for improving the health of a subject comprising an α -(1,2)-branched α -(1,6) oligodextran. U.S. Patent

5 Appl. Pub. No. 2011-0020496A1 discloses a branched dextrin having a structure wherein glucose or isomaltooligosaccharide is linked to a non-reducing terminus of a dextrin through an α -(1,6) glycosidic bond and having a DE of 10 to 52. U.S. Patent 6,630,586 discloses a branched maltodextrin composition comprising 22-35% (1,6) glycosidic linkages; a

10 reducing sugars content of < 20%; a polymolecularity index (Mp/Mn) of < 5; and number average molecular weight (Mn) of 4500 g/mol or less. U.S. Patent 7,612,198 discloses soluble, highly branched glucose polymers, having a reducing sugar content of less than 1%, a level of α -(1,6)

glycosidic bonds of between 13 and 17% and a molecular weight having a

15 value of between 0.9×10^5 and 1.5×10^5 daltons, wherein the soluble highly branched glucose polymers have a branched chain length distribution profile of 70 to 85% of a degree of polymerization (DP) of less than 15, of 10 to 14% of DP of between 15 and 25 and of 8 to 13% of DP greater than 25.

20 Poly α -1,3-glucan has been isolated by contacting an aqueous solution of sucrose with a glucosyltransferase (gtf) enzyme isolated from *Streptococcus salivarius* (Simpson et al., *Microbiology* 141:1451-1460, 1995). U.S. Patent 7,000,000 disclosed the preparation of a polysaccharide fiber using an *S. salivarius* gtfJ enzyme. At least 50% of

25 the hexose units within the polymer of this fiber were linked via α -1,3-glycosidic linkages. The disclosed polymer formed a liquid crystalline solution when it was dissolved above a critical concentration in a solvent or in a mixture comprising a solvent. From this solution continuous, strong, cotton-like fibers, highly suitable for use in textiles, were spun and

30 used.

Development of new glucan polysaccharides and derivatives thereof is desirable given their potential utility in various applications. It is also desirable to identify glucosyltransferase enzymes that can synthesize new glucan polysaccharides, especially those with mixed glycosidic

linkages, and derivatives thereof. The materials would be attractive for use in fabric care and laundry care applications to alter rheology, act as a structuring agent, provide a benefit (preferably a surface substantive effect) to a treated fabric, textile and/or article of clothing (such as improved fabric hand, improved resistance to soil deposition, etc.). Many applications, such as laundry care, often include enzymes such as cellulases, proteases, amylases, and the like. As such, the glucan polysaccharides are preferably resistant to cellulase, amylase, and/or protease activity.

10

SUMMARY

In one embodiment, a fabric care composition is provided comprising:

- a. an α -glucan oligomer/polymer composition comprising:
 - i. 25-35 α -(1,3) glycosidic linkages;
 - 15 ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons;
 - v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - 20 vi. a solubility of at least 20% (w/w) in water at 25 °C; and
 - vii. a polydispersity index of less than 5; and
- b. at least one additional fabric care ingredient.

In another embodiment, a laundry care composition is provided comprising:

- a. an α -glucan oligomer/polymer composition comprising:
 - i. 25-35 α -(1,3) glycosidic linkages;
 - ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - 30 iv. a weight average molecular weight of less than 5000 Daltons;
 - v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;

- vi. a solubility of at least 20% (w/w) in water at 25 °C;
and
 - vii. a polydispersity index of less than 5; and
- b. at least one additional laundry care ingredient.

5

In another embodiment, the additional ingredient in the above fabric care composition or the above laundry care composition is at least one cellulase, at least one protease, at least one amylase or any combination thereof.

- 10 In another embodiment, the fabric care composition or the laundry care composition comprises 0.01 to 90% wt% of the soluble α -glucan oligomer/polymer composition.

- In another embodiment, the fabric care composition or the laundry care composition comprises at least one additional ingredient comprising
- 15 at least one of surfactants (anionic, nonionic, cationic, or zwitterionic), enzymes (proteases, cellulases, polyesterases, amylases, cutinases, lipases, pectate lyases, perhydrolases, xylanases, peroxidases, and/or laccases in any combination), detergent builders, complexing agents, polymers (in addition to the present α -glucan oligomers/polymers and/or α -
- 20 glucan ethers), soil release polymers, surfactancy-boosting polymers , bleaching systems, bleach activators, bleaching catalysts, fabric conditioners, clays, foam boosters, suds suppressors (silicone or fatty-acid based), anti-corrosion agents, soil-suspending agents, anti-soil redeposition agents, dyes, bactericides, tarnish inhibitors, optical
- 25 brighteners, perfumes, saturated or unsaturated fatty acids, dye transfer inhibiting agents, chelating agents, hueing dyes, calcium and magnesium cations, visual signaling ingredients, anti-foam, structurants, thickeners, anti-caking agents, starch, sand, gelling agents, and any combination thereof.

- 30 In another embodiment, a fabric care and/or laundry care composition is provided wherein the composition is in the form of a liquid, a gel, a powder, a hydrocolloid, an aqueous solution, granules, tablets, capsules, single compartment sachets, multi-compartment sachets or any combination thereof.

In another embodiment, the fabric care composition or the laundry care composition is packaged in a unit dose format.

Various glucan ethers may be produced from the present α -glucan oligomers/polymers. In another embodiment, an α -glucan ether

5 composition is provided comprising:

- i. 25-35 α -(1,3) glycosidic linkages;
- ii. 55-75% α -(1,6) glycosidic linkages;
- iii. 5-15% α -(1,3,6) glycosidic linkages;
- iv. a weight average molecular weight of less than 5000
10 Daltons;
- v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
- vi. a solubility of at least 20% (w/w) in water at 25 °C; and
- i. a polydispersity index of less than 5; wherein the glucan
15 ether composition has a degree of substitution (DoS) with at least one organic group of about 0.05 to about 3.0.

The α -glucan ether compositions may be used in a fabric care and/or laundry care formulation comprising enzymes such as a cellulases and proteases. In another embodiment, glucan ether composition is
20 cellulase resistant, protease resistant, amylase resistant or any combination thereof.

The α -glucan ether compositions may be used in a fabric care and/or laundry care and/or personal care compositions. In another embodiment, a personal care composition, fabric care composition or laundry care
25 composition is provided comprising the above α -glucan ether compositions.

In another embodiment, a method for preparing an aqueous composition is provided, the method comprising: contacting an aqueous composition with the above glucan ether composition wherein the aqueous
30 composition comprises at least one cellulase, at least one protease, at least one amylase or any combination thereof.

In another embodiment, a method of treating an article of clothing, textile or fabric is provided comprising:

- a. providing a composition selected from

- i. the above fabric care composition;
- ii. the above laundry care composition;
- iii. the above glucan ether composition;
- iv. the α -glucan oligomer/polymer composition comprising:
 - 5 a. 25-35 α -(1,3) glycosidic linkages;
 - b. 55-75% α -(1,6) glycosidic linkages;
 - c. 5-15% α -(1,3,6) glycosidic linkages;
 - d. a weight average molecular weight of less than 5000 Daltons;
 - 10 e. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - f. a solubility of at least 20% (w/w) in water at 25 °C; and
 - g. a polydispersity index of less than 5; and
- 15 v. any combination of (i) through (iv);
- b. contacting under suitable conditions the composition of (a) with a fabric, textile or article of clothing whereby the fabric, textile or article of clothing is treated and receives a benefit; and
- c. optionally rinsing the treated fabric, textile or article of clothing of
- 20 (b).

In another embodiment of the above method, the α -glucan oligomer/polymer composition or the α -glucan ether composition is a surface substantive.

- 25 In a further embodiment of the above method, the benefit is selected from the group consisting of improved fabric hand, improved resistance to soil deposition, improved colorfastness, improved wear resistance, improved wrinkle resistance, improved antifungal activity, improved stain resistance, improved cleaning performance when laundered, improved drying rates, improved dye, pigment or lake uptake,
- 30 and any combination thereof.

In another embodiment, a method to produce a glucan ether composition is provided comprising:

- a. providing an α -glucan oligomer/polymer composition comprising:
 - i. 25-35 α -(1,3) glycosidic linkages;

- ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons;
 - 5 v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - vi. a solubility of at least 20% (w/w) in water at 25 °C; and
 - vii. a polydispersity index of less than 5;
 - 10 b. contacting the α -glucan oligomer/polymer composition of (a) in a reaction under alkaline conditions with at least one etherification agent comprising an organic group; whereby an α -glucan ether is produced has a degree of substitution (DoS) with at least one organic group of about 0.05 to about 3.0; and
 - 15 c. optionally isolating the α -glucan ether produced in step (b).
- A textile, yarn, fabric or fiber may be modified to comprise (e.g., blended or coated with) the above α -glucan oligomer/polymer composition or the corresponding α -glucan ether composition. In another embodiment, a textile, yarn, fabric or fiber is provided comprising:
- 20 a. an α -glucan oligomer/polymer composition comprising:
 - i. 25-35 α -(1,3) glycosidic linkages;
 - ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons;
 - 25 v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - vi. a solubility of at least 20% (w/w) in water at 25 °C; and
 - 30 vii. a polydispersity index of less than 5;
 - b. a glucan ether composition comprising
 - i. 25-35 α -(1,3) glycosidic linkages;
 - ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;

- iv. a weight average molecular weight of less than 5000 Daltons;
 - v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - 5 vi. a solubility of at least 20% (w/w) in water at 25 °C; and
 - vii. a polydispersity index of less than 5;
- wherein the glucan ether composition has a degree of substitution (DoS) with at least one organic group of
- 10 about 0.05 to about 3.0; or
- c. any combination thereof.

BRIEF DESCRIPTION OF THE BIOLOGICAL SEQUENCES

The following sequences comply with 37 C.F.R. §§ 1.821-1.825

15 (“Requirements for Patent Applications Containing Nucleotide Sequences and/or Amino Acid Sequence Disclosures - the Sequence Rules”) and are consistent with World Intellectual Property Organization (WIPO) Standard ST.25 (2009) and the sequence listing requirements of the European Patent Convention (EPC) and the Patent Cooperation Treaty (PCT) Rules

20 5.2 and 49.5(a-bis), and Section 208 and Annex C of the Administrative Instructions. The symbols and format used for nucleotide and amino acid sequence data comply with the rules set forth in 37 C.F.R. § 1.822.

SEQ ID NO: 1 is the amino acid sequence of the *Paenibacillus humicus* mutanase as provided in GENBANK® gi:257153265 where

25 GENBANK® gi: 257153264 is the corresponding polynucleotide sequence.

SEQ ID NO: 2 is the nucleic acid sequence encoding the *Paenibacillus humicus* mutanase (GENBANK® gi: 257153265 where GENBANK® gi: 257153264 is the corresponding polynucleotide sequence) used for expression in *E. coli* BL21(DE3).

30 SEQ ID NO: 3 is the amino acid sequence of the mature *Paenibacillus humicus* mutanase (GENBANK® gi: 257153264; referred to herein as the “3264 mutanase” or “mut3264”) used for expression in *E. coli* BL21(DE3).

SEQ ID NO: 4 is the amino acid sequence of the *B. subtilis* AprE signal peptide used in the expression vector that was coupled to various enzymes for expression in *B. subtilis*.

5 SEQ ID NO: 5 is the nucleic acid sequence encoding the *Paenibacillus humicus* mutanase used for expression in *B. subtilis* host BG6006.

SEQ ID NO: 6 is the amino acid sequence of the mature *Paenibacillus humicus* mutanase used for expression in *B. subtilis* host BG6006. As used herein, this mutanase may also be referred to herein as
10 “mut3264”.

SEQ ID NO: 7 is the nucleic acid sequence encoding the *Penicillium marneffe* ATCC® 18224™ mutanase.

SEQ ID NO: 8 is the amino acid sequence of the *Penicillium marneffe* ATCC® 18224™ mutanase (GENBANK® gi: 212533325; also
15 referred to herein as the “3325 mutanase” or “mut3325”).

SEQ ID NO: 9 is the polynucleotide sequence of plasmid pTrex3.

SEQ ID NO: 10 is the amino acid sequence of the *Lactobacillus reuteri* glucosyltransferase as found in GENBANK® gi:51574154.

SEQ ID NO: 11 is the nucleic acid sequence encoding a truncated
20 version of the *Lactobacillus reuteri* glucosyltransferase (GENBANK® gi:51574154).

SEQ ID NO: 12 is the amino acid sequence encoding the truncated *Lactobacillus reuteri* glucosyltransferase referred to herein as “GTF4154”.

SEQ ID NO: 13 is the nucleic acid sequence of a polynucleotide
25 terminator sequence.

SEQ ID NO: 14 is the nucleic acid sequence of a polynucleotide linker sequence.

DETAILED DESCRIPTION

30 In this disclosure, a number of terms and abbreviations are used. The following definitions apply unless specifically stated otherwise.

As used herein, the articles “a”, “an”, and “the” preceding an element or component are intended to be nonrestrictive regarding the number of instances (*i.e.*, occurrences) of the element or component.

Therefore “a”, “an”, and “the” should be read to include one or at least one, and the singular word form of the element or component also includes the plural unless the number is obviously meant to be singular.

As used herein, the term “comprising” means the presence of the
5 stated features, integers, steps, or components as referred to in the claims, but that it does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof. The term “comprising” is intended to include embodiments encompassed by the terms “consisting essentially of” and “consisting of”. Similarly, the term
10 “consisting essentially of” is intended to include embodiments encompassed by the term “consisting of”.

As used herein, the term “about” modifying the quantity of an ingredient or reactant employed refers to variation in the numerical quantity that can occur, for example, through typical measuring and liquid
15 handling procedures used for making concentrates or use solutions in the real world; through inadvertent error in these procedures; through differences in the manufacture, source, or purity of the ingredients employed to make the compositions or carry out the methods; and the like. The term “about” also encompasses amounts that differ due to different
20 equilibrium conditions for a composition resulting from a particular initial mixture. Whether or not modified by the term “about”, the claims include equivalents to the quantities.

Where present, all ranges are inclusive and combinable. For example, when a range of “1 to 5” is recited, the recited range should be
25 construed as including ranges “1 to 4”, “1 to 3”, “1-2”, “1-2 & 4-5”, “1-3 & 5”, and the like.

As used herein, the term “obtainable from” shall mean that the source material (for example, sucrose) is capable of being obtained from a specified source, but is not necessarily limited to that specified source.

30 As used herein, the term “effective amount” will refer to the amount of the substance used or administered that is suitable to achieve the desired effect. The effective amount of material may vary depending upon the application. One of skill in the art will typically be able to determine an

effective amount for a particular application or subject without undo experimentation.

The terms "percent by volume", "volume percent", "vol %" and "v/v %" are used interchangeably herein. The percent by volume of a solute in a solution can be determined using the formula: [(volume of
5 solute)/(volume of solution)] x 100%.

The terms "percent by weight", "weight percentage (wt %)" and "weight-weight percentage (% w/w)" are used interchangeably herein. Percent by weight refers to the percentage of a material on a mass basis
10 as it is comprised in a composition, mixture, or solution.

The terms "increased", "enhanced" and "improved" are used interchangeably herein. These terms refer to a greater quantity or activity such as a quantity or activity slightly greater than the original quantity or activity, or a quantity or activity in large excess compared to the original
15 quantity or activity, and including all quantities or activities in between. Alternatively, these terms may refer to, for example, a quantity or activity that is at least 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 15%, 16%, 17%, 18%, 19% or 20% more than the quantity or activity for which the increased quantity or activity is being compared.

20 As used herein, the term "isolated" means a substance in a form or environment that does not occur in nature. Non-limiting examples of isolated substances include (1) any non- naturally occurring substance, (2) any substance including, but not limited to, any host cell, enzyme, variant, nucleic acid, protein, peptide or cofactor, that is at least partially
25 removed from one or more or all of the naturally occurring constituents with which it is associated in nature; (3) any substance modified by the hand of man relative to that substance found in nature; or (4) any substance modified by increasing the amount of the substance relative to other components with which it is naturally associated.

30 As used herein, term "water soluble" will refer to the present glucan oligomer/polymer compositions that are soluble at 20 wt% or higher in pH 7 water at 25°C.

As used herein, the terms "soluble glucan fiber", "α-glucan fiber", "α-glucan polymer", "α-glucan oligosaccharide", "α-glucan polysaccharide",

“α-glucan oligomer”, “α-glucan oligomer/polymer”, “α-glucan polymer”, and “soluble glucan fiber composition” refer to the present α-glucan polymer composition (non-derivatized; i.e., not an α-glucan ether) comprised of water soluble glucose oligomers having a glucose polymerization degree of 3 or more. The present soluble glucan polymer composition is enzymatically synthesized from sucrose (α-D-Glucopyranosyl β-D-fructofuranoside; CAS# 57-50-1) obtainable from, for example, sugarcane and/or sugar beets. In one embodiment, the present soluble α-glucan polymer composition is not alternan or maltoalternan oligosaccharide.

As used herein, “weight average molecular weight” or “ M_w ” is calculated as

$M_w = \sum N_i M_i^2 / \sum N_i M_i$; where M_i is the molecular weight of a chain and N_i is the number of chains of that molecular weight. The weight average molecular weight can be determined by technics such as static light scattering, small angle neutron scattering, X-ray scattering, and sedimentation velocity.

As used herein, “number average molecular weight” or “ M_n ” refers to the statistical average molecular weight of all the polymer chains in a sample. The number average molecular weight is calculated as $M_n = \sum N_i M_i / \sum N_i$ where M_i is the molecular weight of a chain and N_i is the number of chains of that molecular weight. The number average molecular weight of a polymer can be determined by technics such as gel permeation chromatography, viscometry via the (Mark-Houwink equation), and colligative methods such as vapor pressure osmometry, end-group determination or proton NMR.

As used herein, “polydispersity index”, “PDI”, “heterogeneity index”, and “dispersity” refer to a measure of the distribution of molecular mass in a given polymer (such as a glucose oligomer) sample and can be calculated by dividing the weight average molecular weight by the number average molecular weight ($PDI = M_w/M_n$).

It shall be noted that the terms “glucose” and “glucopyranose” as used herein are considered as synonyms and used interchangeably. Similarly the terms “glucosyl” and “glucopyranosyl” units are used herein are considered as synonyms and used interchangeably.

As used herein, "glycosidic linkages" or "glycosidic bonds" will refer to the covalent the bonds connecting the sugar monomers within a saccharide oligomer (oligosaccharides and/or polysaccharides). Example of glycosidic linkage may include α -linked glucose oligomers with 1,6- α -D-glycosidic linkages (herein also referred to as α -D-(1,6) linkages or simply " α -(1,6)" linkages); 1,3- α -D-glycosidic linkages (herein also referred to as α -D-(1,3) linkages or simply " α -(1,3)" linkages; 1,4- α -D-glycosidic linkages (herein also referred to as α -D-(1,4) linkages or simply " α -(1,4)" linkages; 1,2- α -D-glycosidic linkages (herein also referred to as α -D-(1,2) linkages or simply " α -(1,2)" linkages; and combinations of such linkages typically associated with branched saccharide oligomers.

As used herein, the terms "glucansucrase", "glucosyltransferase", "glucoside hydrolase type 70", "GTF", and "GS" will refer to transglucosidases classified into family 70 of the glycoside-hydrolases typically found in lactic acid bacteria such as *Streptococcus*, *Leuconostoc*, *Weisella* or *Lactobacillus* genera (see Carbohydrate Active Enzymes database; "CAZy"; Cantarel *et al.*, (2009) *Nucleic Acids Res* 37:D233-238). The GTF enzymes are able to polymerize the D-glucosyl units of sucrose to form homooligosaccharides or homopolysaccharides. Depending upon the specificity of the GTF enzyme, linear and/or branched glucans comprising various glycosidic linkages may be formed such as α -(1,2), α -(1,3), α -(1,4) and α -(1,6). Glucosyltransferases may also transfer the D-glucosyl units onto hydroxyl acceptor groups. A non-limiting list of acceptors may include carbohydrates, alcohols, polyols or flavonoids. Specific acceptors may also include maltose, isomaltose, isomaltotriose, and methyl- α -D-glucan, to name a few. The structure of the resultant glucosylated product is dependent upon the enzyme specificity. In one embodiment, the polypeptide having glucosyltransferase activity comprises an amino acid sequence having at least 90%, preferably at least 91, 92, 93, 94, 95, 96, 97, 98, 99 or 100% identity to SEQ ID NO: 10 or 12. In a further embodiment, the polypeptide having glucosyltransferase activity comprises an amino acid sequence having at least 95% identity, preferably 96, 97, 98, 99 or 100% identity to SEQ ID

NO: 12. In one aspect, the glucosyltransferase is expressed in a truncated and/or mature form.

As used herein, the term “isomaltooligosaccharide” or “IMO” refers to a glucose oligomers comprised essentially of α -D-(1,6) glycosidic linkage typically having an average size of DP 2 to 20. Isomaltooligosaccharides can be produced commercially from an enzymatic reaction of α -amylase, pullulanase, β -amylase, and α -glucosidase upon corn starch or starch derivative products. Commercially available products comprise a mixture of isomaltooligosaccharides (DP ranging from 3 to 8, e.g., isomaltotriose, isomaltotetraose, isomaltopentaose, isomaltohexaose, isomaltoheptaose, isomaltooctaose) and may also include panose.

As used herein, the term “dextran” refers to water soluble α -glucans comprising at least 95% α -D-(1,6) glycosidic linkages (typically with up to 5% α -D-(1,3) glycosidic linkages at branching points). Dextrans often have an average molecular weight above 1000 kDa. As used herein, enzymes capable of synthesizing dextran from sucrose may be described as “dextransucrases” (EC 2.4.1.5).

As used herein, the term “mutan” refers to water insoluble α -glucans comprised primarily (50% or more of the glycosidic linkages present) of 1,3- α -D glycosidic linkages and typically have a degree of polymerization (DP) that is often greater than 9. Enzymes capable of synthesizing mutan or α -glucan oligomers comprising greater than 50% 1,3- α -D glycosidic linkages from sucrose may be described as “mutansucrases” (EC 2.4.1.-) with the proviso that the enzyme does not produce alternan.

As used herein, the term “alternan” refers to α -glucans having alternating 1,3- α -D glycosidic linkages and 1,6- α -D glycosidic linkages over at least 50% of the linear oligosaccharide backbone. Enzymes capable of synthesizing alternan from sucrose may be described as “alternansucrases” (EC 2.4.1.140).

As used herein, the term “reuteran” refers to soluble α -glucan comprised 1,4- α -D-glycosidic linkages (typically > 50%); 1,6- α -D-glycosidic linkages; and 4,6-disubstituted α -glucosyl units at the branching

points. Enzymes capable of synthesizing reuteran from sucrose may be described as “reuteransucrases” (EC 2.4.1.-).

As used herein, the terms “ α -glucanohydrolase” and “glucanohydrolase” will refer to an enzyme capable of hydrolyzing an α -glucan oligomer. As used herein, the glucanohydrolase may be defined by the endohydrolysis activity towards certain α -D-glycosidic linkages. Examples may include, but are not limited to, dextranases (EC 3.2.1.1; capable of endohydrolyzing α -(1,6)-linked glycosidic bonds), mutanases (EC 3.2.1.59; capable of endohydrolyzing α -(1,3)-linked glycosidic bonds), and alternanases (EC 3.2.1.-; capable of endohydrolytically cleaving alternan). Various factors including, but not limited to, level of branching, the type of branching, and the relative branch length within certain α -glucans may adversely impact the ability of an α -glucanohydrolase to endohydrolyze some glycosidic linkages.

As used herein, the term “dextranase” (α -1,6-glucan-6-glucanohydrolase; EC 3.2.1.11) refers to an enzyme capable of endohydrolysis of 1,6- α -D-glycosidic linkages (the linkage predominantly found in dextran). Dextranases are known to be useful for a number of applications including the use as ingredient in dentifrice for prevention of dental caries, plaque and/or tartar and for hydrolysis of raw sugar juice or syrup of sugar canes and sugar beets. Several microorganisms are known to be capable of producing dextranases, among them fungi of the genera *Penicillium*, *Paecilomyces*, *Aspergillus*, *Fusarium*, *Spicaria*, *Verticillium*, *Helminthosporium* and *Chaetomium*; bacteria of the genera *Lactobacillus*, *Streptococcus*, *Cellvibrio*, *Cytophaga*, *Brevibacterium*, *Pseudomonas*, *Corynebacterium*, *Arthrobacter* and *Flavobacterium*, and yeasts such as *Lipomyces starkeyi*. Food grade dextranases are commercially available. An example of a food grade dextrinase is DEXTRANASE® Plus L, an enzyme from *Chaetomium erraticum* sold by Novozymes A/S, Bagsvaerd, Denmark. In a preferred aspect, the dextranase is the *Chaetomium erraticum* dextranase. In further embodiment, the dextranase is Dextranase L from *Chaetomium erraticum*.

As used herein, the term “mutanase” (glucan endo-1,3- α -glucosidase; EC 3.2.1.59) refers to an enzyme which hydrolytically cleaves

1,3- α -D-glycosidic linkages (the linkage predominantly found in mutan).

Mutanases are available from a variety of bacterial and fungal sources. A non-limiting list of mutanases is provided as amino acid sequences 1, 3, 6, and 8. In a preferred embodiment, the mutanase comprises an amino acid
5 sequence having at least 90% identity, preferably 91, 92, 93, 94, 95, 96, 97, 98, 99 or 100% identity to SEQ ID NOs 1, 3, 6 or 8. In a further preferred embodiment, the mutanase comprises at least 95% identity, preferably 96, 97, 98, 99 or 100% identity to SEQ ID NO: 3.

As used herein, the term "alternanase" (EC 3.2.1.-) refers to an
10 enzyme which endo-hydrolytically cleaves alternan (U.S. 5,786,196 to Cote *et al.*).

As used herein, the term "wild type enzyme" will refer to an enzyme (full length and active truncated forms thereof) comprising the amino acid sequence as found in the organism from which it was obtained and/or
15 annotated. The enzyme (full length or catalytically active truncation thereof) may be recombinantly produced in a microbial host cell. The enzyme is typically purified prior to being used as a processing aid in the production of the present soluble α -glucan oligomer/polymer composition. In one aspect, a combination of at least two wild type enzymes
20 simultaneously present in the reaction system is used in order to obtain the present α -glucan polymer composition. In another aspect, under certain reaction conditions (for example, a reaction temperature around 47 °C to 50 °C) it may be possible to use a single wild type glucosyltransferase to produce the present soluble α -glucan polymer (see
25 Examples 38, 44, and 45). In another aspect, the present method comprises a single reaction chamber comprising at least one glucosyltransferase capable of forming a soluble α -glucan polymer composition comprising 50% or more α -(1,3) glycosidic linkages (such as a mutansucrase) and at least one α -glucanohydrolase having
30 endohydrolysis activity for the α -glucan synthesized from the glucosyltransferase(s) present in the reaction system.

As used herein, the terms "substrate for the enzymatic reaction" and "suitable substrate for α -glucan polymer synthesis" will refer to a composition comprising sucrose. In one embodiment, the substrate

composition may further comprise one or more suitable acceptors, such as maltose, isomaltose, isomaltotriose, and methyl- α -D-glucan, to name a few. In one embodiment, a combination of at least one glucosyltransferase capable for forming glucose oligomers is used in combination with at least one α -glucanohydrolase in the same reaction mixture (*i.e.*, they are simultaneously present and active in the reaction mixture). As such the “substrate” for the α -glucanohydrolase is the glucose oligomers concomitantly being synthesized in the reaction system by the glucosyltransferase from sucrose. In one aspect, a two-enzyme method (*i.e.*, at least one glucosyltransferase (GTF) and at least one α -glucanohydrolase) where the enzymes are not used concomitantly in the reaction mixture is excluded, by proviso, from the present methods.

As used herein, the terms “suitable enzymatic reaction mixture”, “suitable enzymatic reaction components”, “suitable enzymatic aqueous reaction mixture”, and “enzymatic reaction mixture”, refer to the materials (suitable substrate(s)) and water in which the reactants come into contact with the enzyme(s). The suitable reaction components may be comprised of a plurality of enzymes. In one aspect, the suitable reaction components comprises at least one glucansucrase enzyme. In a further aspect, the suitable reaction components comprise at least one glucansucrase and at least one α -glucanohydrolase.

As used herein, “one unit of glucansucrase activity” or “one unit of glucosyltransferase activity” is defined as the amount of enzyme required to convert 1 μ mol of sucrose per minute when incubated with 200 g/L sucrose at pH 5.5 and 37 °C. The sucrose concentration was determined using HPLC.

As used herein, “one unit of dextranase activity” is defined as the amount of enzyme that forms 1 μ mol reducing sugar per minute when incubated with 0.5 mg/mL dextran substrate at pH 5.5 and 37 °C. The reducing sugars were determined using the PAHBAH assay (Lever M., (1972), A New Reaction for Colorimetric Determination of Carbohydrates, *Anal. Biochem.* 47, 273-279).

As used herein, “one unit of mutanase activity” is defined as the amount of enzyme that forms 1 μ mol reducing sugar per minute when

incubated with 0.5 mg/mL mutan substrate at pH 5.5 and 37 °C. The reducing sugars were determined using the PAHBAH assay (Lever M., *supra*).

As used herein, the term “enzyme catalyst” refers to a catalyst comprising an enzyme or combination of enzymes having the necessary activity to obtain the desired soluble α -glucan polymer composition. In certain embodiments, a combination of enzyme catalysts may be required to obtain the desired soluble glucan polymer composition. The enzyme catalyst(s) may be in the form of a whole microbial cell, permeabilized microbial cell(s), one or more cell components of a microbial cell extract(s), partially purified enzyme(s) or purified enzyme(s). In certain embodiments the enzyme catalyst(s) may also be chemically modified (such as by pegylation or by reaction with cross-linking reagents). The enzyme catalyst(s) may also be immobilized on a soluble or insoluble support using methods well-known to those skilled in the art; see for example, Immobilization of Enzymes and Cells; Gordon F. Bickerstaff, Editor; Humana Press, Totowa, NJ, USA; 1997.

The term “resistance to enzymatic hydrolysis” will refer to the relative stability of the present materials (α -glucan oligomers/polymers and/or the corresponding α -glucan ether compounds produced by the etherification of the present α -glucan oligomers/polymers) to enzymatic hydrolysis. The resistance to hydrolysis will be particularly important for use of the present materials in applications wherein enzymes are often present, such as in fabric care and laundry care applications. In one embodiment, the α -glucan oligomers/polymers and/or the corresponding α -glucan ether compounds produced by the etherification of the present α -glucan oligomers/polymers are resistant to cellulases (i.e., cellulase resistant). In another embodiment, the α -glucan oligomers/polymers and/or the corresponding α -glucan ether compounds produced by the etherification of the present α -glucan oligomers/polymers are resistant to proteases (i.e., protease resistant). In another embodiment, the α -glucan oligomers/polymers and/or the corresponding α -glucan ether compounds produced by the etherification of the present α -glucan oligomers/polymers are resistant to amylases (i.e., amylase resistant). In a preferred aspect,

α -glucan oligomers/polymers and/or the corresponding α -glucan ether compounds produced by the etherification of the present α -glucan oligomers/polymers are resistant to multiple classes of enzymes (combinations of cellulases, proteases, and/or amylases). Resistance to any particular enzyme will be defined as having at least 50%, preferably at least 60, 70, 80, 90, 95 or 100% of the materials remaining after treatment with the respective enzyme. The % remaining may be determined by measuring the supernatant after enzyme treatment using SEC-HPLC. The assay to measure enzyme resistance may using the following: A sample of the soluble material (e.g., 100 mg to is added to 10.0 mL water in a 20-mL scintillation vial and mixed using a PTFE magnetic stir bar to create a 1 wt% solution. The reaction is run at pH 7.0 at 20 °C. After the fiber is complete dissolved, 1.0 mL (1 wt% enzyme formulation) of cellulase (PURADEx® EGL), amylase (PURASTAR® ST L) or protease (SAVINASE® 16.0L) is added and the solution is mixed for 72 hrs at 20 °C. The reaction mixture is heated to 70 °C for 10 minutes to inactivate the added enzyme, and the resulting mixture is cooled to room temperature and centrifuged to remove any precipitate. The supernatant is analyzed by SEC-HPLC for recovered oligomers/polymers and compared to a control where no enzyme was added to the reaction mixture. Percent changes in area counts for the respective oligomers/polymers may be used to test the relative resistance of the materials to the respective enzyme treatment. Percent changes in area count for total \geq DP3+ fibers will be used to assess the relative amount of materials remaining after treatment with a particular enzyme. Materials having a percent recovery of at least 50%, preferably at least 60, 70, 80, 90, 95 or 100% will be considered resistant to the respective enzyme treatment (e.g., "cellulase resistant", "protease resistant" and/or "amylase resistant").

The terms " α -glucan ether compound", " α -glucan ether composition", " α -glucan ether", and " α -glucan ether derivative" are used interchangeably herein. An α -glucan ether compound herein is the present α -glucan polymer that has been etherified with one or more organic groups such that the compound has a degree of substitution (DoS) with one or more organic groups of about 0.05 to about 3.0. Such

etherification occurs at one or more hydroxyl groups of at least 30% of the glucose monomeric units of the α -glucan polymer.

An α -glucan ether compound is termed an "ether" herein by virtue of comprising the substructure $-C_G-O-C-$, where " $-C_G-$ " represents a carbon atom of a glucose monomeric unit of an α -glucan ether compound (where
5 such carbon atom was bonded to a hydroxyl group $[-OH]$ in the α -glucan polymer precursor of the ether), and where " $-C-$ " is a carbon atom of the organic group. Thus, for example, with regard to a glucose monomeric unit (G) involved in $-1,3-G-1,3-$ within an ether herein, C_G atoms 2, 4
10 and/or 6 of the glucose (G) may independently be linked to an OH group or be in ether linkage to an organic group. Similarly, for example, with regard to a glucose monomeric unit (G) involved in $-1,3-G-1,6-$ within an ether herein, C_G atoms 2, 4 and/or 6 of the glucose (G) may independently be linked to an OH group or be in ether linkage to an organic group. Also,
15 for example, with regard to a glucose monomeric unit (G) involved in $-1,6-G-1,6-$ within an ether herein, C_G atoms 2, 3 and/or 4 of the glucose (G) may independently be linked to an OH group or be in ether linkage to an organic group. Similarly, for example, with regard to a glucose monomeric unit (G) involved in $-1,6-G-1,3-$ within an ether herein, C_G atoms 2, 3
20 and/or 4 of the glucose (G) may independently be linked to an OH group or be in ether linkage to an organic group.

It would be understood that a "glucose" monomeric unit of an α -glucan ether compound herein typically has one or more organic groups in ether linkage. Thus, such a glucose monomeric unit can also be referred
25 to as an etherized glucose monomeric unit.

The α -glucan ether compounds disclosed herein are synthetic, man-made compounds. Likewise, compositions comprising the present α -glucan polymer are synthetic, man-made compounds.

An "organic group" group as used herein can refer to a chain of one
30 or more carbons that (i) has the formula $-C_nH_{2n+1}$ (i.e., an alkyl group, which is completely saturated) or (ii) is mostly saturated but has one or more hydrogens substituted with another atom or functional group (i.e., a "substituted alkyl group"). Such substitution may be with one or more hydroxyl groups, oxygen atoms (thereby forming an aldehyde or ketone

group), carboxyl groups, or other alkyl groups. Thus, as examples, an organic group herein can be an alkyl group, carboxy alkyl group, or hydroxy alkyl group. An organic group herein may thus be uncharged or anionic (an example of an anionic organic group is a carboxy alkyl group).

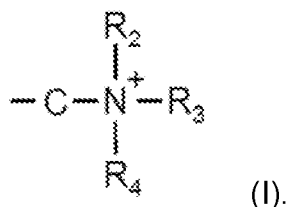
5 A “carboxy alkyl” group herein refers to a substituted alkyl group in which one or more hydrogen atoms of the alkyl group are substituted with a carboxyl group. A “hydroxy alkyl” group herein refers to a substituted alkyl group in which one or more hydrogen atoms of the alkyl group are substituted with a hydroxyl group.

10 An “organic group” can alternatively refer to a “positively charged organic group”. A positively charged organic group as used herein refers to a chain of one or more carbons (“carbon chain”) that has one or more hydrogens substituted with another atom or functional group (i.e., a “substituted alkyl group”), where one or more of the substitutions is with a
15 positively charged group. Where a positively charged organic group has a substitution in addition to a substitution with a positively charged group, such additional substitution may be with one or more hydroxyl groups, oxygen atoms (thereby forming an aldehyde or ketone group), alkyl groups, and/or additional positively charged groups. A positively charged
20 organic group has a net positive charge since it comprises one or more positively charged groups.

 The terms “positively charged group”, “positively charged ionic group” and “cationic group” are used interchangeably herein. A positively charged group comprises a cation (a positively charged ion). Examples of
25 positively charged groups include substituted ammonium groups, carbocation groups and acyl cation groups.

 A composition that is “positively charged” is repelled from other positively charged substances, but attracted to negatively charged substances.

30 The terms “substituted ammonium group”, “substituted ammonium ion” and “substituted ammonium cation” are used interchangeably herein. A substituted ammonium group herein comprises structure I:

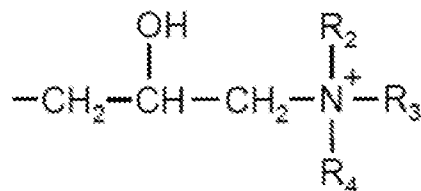


R₂, R₃ and R₄ in structure I each independently represent a hydrogen atom or an alkyl, aryl, cycloalkyl, aralkyl, or alkaryl group. The carbon atom (C) in structure I is part of the chain of one or more carbons ("carbon chain") of the positively charged organic group. The carbon atom is either
 5 directly ether-linked to a glucose monomer of the α-glucan polymer, or is part of a chain of two or more carbon atoms ether-linked to a glucose monomer of the α-glucan polymer/oligomer. The carbon atom in structure I can be -CH₂-, -CH- (where a H is substituted with another group such as
 10 a hydroxy group), or -C- (where both H's are substituted).

A substituted ammonium group can be a "primary ammonium group", "secondary ammonium group", "tertiary ammonium group", or "quaternary ammonium" group, depending on the composition of R₂, R₃ and R₄ in structure I. A primary ammonium group herein refers to
 15 structure I in which each of R₂, R₃ and R₄ is a hydrogen atom (i.e., -C-NH₃⁺). A secondary ammonium group herein refers to structure I in which each of R₂ and R₃ is a hydrogen atom and R₄ is an alkyl, aryl, or cycloalkyl group. A tertiary ammonium group herein refers to structure I in which R₂ is a hydrogen atom and each of R₃ and R₄ is an alkyl, aryl, or
 20 cycloalkyl group. A quaternary ammonium group herein refers to structure I in which each of R₂, R₃ and R₄ is an alkyl, aryl, or cycloalkyl group (i.e., none of R₂, R₃ and R₄ is a hydrogen atom).

A quaternary ammonium poly alpha-1,3-1,6-glucan ether herein can comprise a trialkyl ammonium group (where each of R₂, R₃ and R₄ is an
 25 alkyl group), for example. A trimethylammonium group is an example of a trialkyl ammonium group, where each of R₂, R₃ and R₄ is a methyl group. It would be understood that a fourth member (i.e., R₁) implied by "quaternary" in this nomenclature is the chain of one or more carbons of the positively charged organic group that is ether-linked to a glucose
 30 monomer of the present α-glucan polymer/oligomer.

An example of a quaternary ammonium α -glucan ether compound is trimethylammonium hydroxypropyl α -glucan. The positively charged organic group of this ether compound can be represented as structure II:



(II), where each of R_2 , R_3 and R_4 is a

5 methyl group. Structure II is an example of a quaternary ammonium hydroxypropyl group.

A “halide” herein refers to a compound comprising one or more halogen atoms (e.g., fluorine, chlorine, bromine, iodine). A halide herein can refer to a compound comprising one or more halide groups such as
10 fluoride, chloride, bromide, or iodide. A halide group may serve as a reactive group of an etherification agent.

When referring to the non-enzymatic etherification reaction, the terms “reaction”, “reaction composition”, and “etherification reaction” are used interchangeably herein and refer to a reaction comprising at least α -
15 glucan polymer and an etherification agent. These components are typically mixed (e.g., resulting in a slurry) and/or dissolved in a solvent (organic and/or aqueous) comprising alkali hydroxide. A reaction is placed under suitable conditions (e.g., time, temperature) for the etherification agent to etherify one or more hydroxyl groups of the glucose units of α -
20 glucan polymer/oligomer with an organic group, thereby yielding an α -glucan ether compound.

The term “alkaline conditions” herein refers to a solution or mixture pH of at least 10, 11 or 12. Alkaline conditions can be prepared by any means known in the art, such as by dissolving an alkali hydroxide in a
25 solution or mixture.

The terms “etherification agent” and “alkylation agent” are used interchangeably herein. An etherification agent herein refers to an agent that can be used to etherify one or more hydroxyl groups of one or more glucose units of the present α -glucan polymer/oligomer with an organic
30 group. An etherification agent thus comprises an organic group.

The term "degree of substitution" (DoS) as used herein refers to the average number of hydroxyl groups substituted in each monomeric unit (glucose) of the present α -glucan ether compound. Since there are at most three hydroxyl groups in a glucose monomeric unit in an α -glucan polymer/oligomer, the degree of substitution in an α -glucan ether compound herein can be no higher than 3.

The term "molar substitution" (M.S.) as used herein refers to the moles of an organic group per monomeric unit of the present α -glucan ether compound. Alternatively, M.S. can refer to the average moles of etherification agent used to react with each monomeric unit in the present α -glucan oligomer/polymer (M.S. can thus describe the degree of derivatization with an etherification agent). It is noted that the M.S. value for the present α -glucan may have no upper limit. For example, when an organic group containing a hydroxyl group (e.g., hydroxyethyl or hydroxypropyl) has been etherified to α -glucan, the hydroxyl group of the organic group may undergo further reaction, thereby coupling more of the organic group to the α -glucan oligomer/polymer.

The term "crosslink" herein refers to a chemical bond, atom, or group of atoms that connects two adjacent atoms in one or more polymer molecules. It should be understood that, in a composition comprising crosslinked α -glucan ether, crosslinks can be between at least two α -glucan ether molecules (i.e., intermolecular crosslinks); there can also be intramolecular crosslinking. A "crosslinking agent" as used herein is an atom or compound that can create crosslinks.

An "aqueous composition" herein refers to a solution or mixture in which the solvent is at least about 20 wt% water, for example, and which comprises the present α -glucan oligomer/polymer and/or the present α -glucan ether compound derivable from etherification of the present α -glucan oligomer/polymer. Examples of aqueous compositions herein are aqueous solutions and hydrocolloids.

The terms "hydrocolloid" and "hydrogel" are used interchangeably herein. A hydrocolloid refers to a colloid system in which water is the dispersion medium. A "colloid" herein refers to a substance that is microscopically dispersed throughout another substance. Therefore, a

hydrocolloid herein can also refer to a dispersion, emulsion, mixture, or solution of α -glucan oligomer/polymer and/or one or more α -glucan ether compounds in water or aqueous solution.

5 The term "aqueous solution" herein refers to a solution in which the solvent is water. The present α -glucan oligomer/polymer and/or the present α -glucan ether compounds can be dispersed, mixed, and/or dissolved in an aqueous solution. An aqueous solution can serve as the dispersion medium of a hydrocolloid herein.

10 The terms "dispersant" and "dispersion agent" are used interchangeably herein to refer to a material that promotes the formation and stabilization of a dispersion of one substance in another. A 'dispersion' herein refers to an aqueous composition comprising one or more particles (e.g., any ingredient of a personal care product, pharmaceutical product, food product, household product, or industrial
15 product disclosed herein) that are scattered, or uniformly scattered, throughout the aqueous composition. It is believed that the present α -glucan oligomer/polymer and/or the present α -glucan ether compounds can act as dispersants in aqueous compositions disclosed herein.

20 The term "viscosity" as used herein refers to the measure of the extent to which a fluid or an aqueous composition such as a hydrocolloid resists a force tending to cause it to flow. Various units of viscosity that can be used herein include centipoise (cPs) and Pascal-second (Pa·s). A centipoise is one one-hundredth of a poise; one poise is equal to $0.100 \text{ kg} \cdot \text{m}^{-1} \cdot \text{s}^{-1}$. Thus, the terms "viscosity modifier" and "viscosity-modifying
25 agent" as used herein refer to anything that can alter/modify the viscosity of a fluid or aqueous composition.

The term "shear thinning behavior" as used herein refers to a decrease in the viscosity of the hydrocolloid or aqueous solution as shear rate increases. The term "shear thickening behavior" as used herein
30 refers to an increase in the viscosity of the hydrocolloid or aqueous solution as shear rate increases. "Shear rate" herein refers to the rate at which a progressive shearing deformation is applied to the hydrocolloid or aqueous solution. A shearing deformation can be applied rotationally.

The term "contacting" as used herein with respect to methods of altering the viscosity of an aqueous composition refers to any action that results in bringing together an aqueous composition with the present α -glucan polymer composition and/or α -glucan ether compound.

- 5 "Contacting" may also be used herein with respect to treating a fabric, textile, yarn or fiber with the present α -glucan polymer and/or α -glucan ether compound to provide a surface substantive effect. Contacting can be performed by any means known in the art, such as dissolving, mixing, shaking, homogenization, spraying, treating, immersing, flushing, pouring
10 on or in, combining, painting, coating, applying, affixing to and otherwise communicating an effective amount of the α -glucan polymer composition and/or α -glucan ether compound to an aqueous composition and/or directly to a fabric, fiber, yarn or textile to achieve the desired effect.

- The terms "fabric", "textile", and "cloth" are used interchangeably
15 herein to refer to a woven or non-woven material having a network of natural and/or artificial fibers. Such fibers can be thread or yarn, for example.

- A "fabric care composition" herein is any composition suitable for treating fabric in some manner. Examples of such a composition include
20 non-laundering fiber treatments (for desizing, scouring, mercerizing, bleaching, coloration, dyeing, printing, bio-polishing, anti-microbial treatments, anti-wrinkle treatments, stain resistance treatments, etc.), laundry care compositions (e.g., laundry care detergents), and fabric softeners.

- 25 The terms "heavy duty detergent" and "all-purpose detergent" are used interchangeably herein to refer to a detergent useful for regular washing of white and colored textiles at any temperature. The terms "low duty detergent" or "fine fabric detergent" are used interchangeably herein to refer to a detergent useful for the care of delicate fabrics such as
30 viscose, wool, silk, microfiber or other fabric requiring special care. "Special care" can include conditions of using excess water, low agitation, and/or no bleach, for example.

The term "adsorption" herein refers to the adhesion of a compound (e.g., the present α -glucan polymer/oligomer and/or the present α -glucan

ether compounds derived from the present α -glucan polymer/oligomers) to the surface of a material.

The terms "cellulase" and "cellulase enzyme" are used interchangeably herein to refer to an enzyme that hydrolyzes β -1,4-D-glucosidic linkages in cellulose, thereby partially or completely degrading cellulose. Cellulase can alternatively be referred to as " β -1,4-glucanase", for example, and can have endocellulase activity (EC 3.2.1.4), exocellulase activity (EC 3.2.1.91), or cellobiase activity (EC 3.2.1.21). A cellulase in certain embodiments herein can also hydrolyze β -1,4-D-glucosidic linkages in cellulose ether derivatives such as carboxymethyl cellulose. "Cellulose" refers to an insoluble polysaccharide having a linear chain of β -1,4-linked D-glucose monomeric units.

As used herein, the term "fabric hand" or "handle" is meant people's tactile sensory response towards fabric which may be physical, physiological, psychological, social or any combination thereof. In one embodiment, the fabric hand may be measured using a PhabrOmeter[®] System for measuring relative hand value (available from Nu Cybertek, Inc. Davis, CA) (American Association of Textile Chemists and Colorists (AATCC test method "202-2012, Relative Hand Value of Textiles: Instrumental Method").

As used herein, "pharmaceutically-acceptable" means that the compounds or compositions in question are suitable for use in contact with the tissues of humans and other animals without undue toxicity, incompatibility, instability, irritation, allergic response, and the like, commensurate with a reasonable benefit/risk ratio.

As used herein, the term "oligosaccharide" refers to polymers typically containing between 3 and about 30 monosaccharide units linked by α -glycosidic bonds.

As used herein the term "polysaccharide" refers to polymers typically containing greater than 30 monosaccharide units linked by α -glycosidic bonds.

As used herein, "personal care products" means products used in the cosmetic treatment hair, skin, scalp, and teeth, including, but not limited to shampoos, body lotions, shower gels, topical moisturizers,

toothpaste, tooth gels, mouthwashes, mouthrinses, anti-plaque rinses, and/or other topical treatments. In some particularly preferred embodiments, these products are utilized on humans, while in other embodiments, these products find cosmetic use with non-human animals (e.g., in certain veterinary applications).

As used herein, an “isolated nucleic acid molecule”, “isolated polynucleotide”, and “isolated nucleic acid fragment” will be used interchangeably and refer to a polymer of RNA or DNA that is single- or double-stranded, optionally containing synthetic, non-natural or altered nucleotide bases. An isolated nucleic acid molecule in the form of a polymer of DNA may be comprised of one or more segments of cDNA, genomic DNA or synthetic DNA.

The term “amino acid” refers to the basic chemical structural unit of a protein or polypeptide. The following abbreviations are used herein to identify specific amino acids:

| <u>Amino Acid</u> | <u>Three-Letter Abbreviation</u> | <u>One-Letter Abbreviation</u> |
|-------------------|--------------------------------------|------------------------------------|
| Alanine | Ala | A |
| Arginine | Arg | R |
| Asparagine | Asn | N |
| Aspartic acid | Asp | D |
| Cysteine | Cys | C |
| Glutamine | Gln | Q |
| Glutamic acid | Glu | E |
| Glycine | Gly | G |
| Histidine | His | H |
| Isoleucine | Ile | I |
| Leucine | Leu | L |
| Lysine | Lys | K |
| Methionine | Met | M |
| Phenylalanine | Phe | F |
| Proline | Pro | P |
| Serine | Ser | S |

| | | |
|-------------------------------------|-----|---|
| Threonine | Thr | T |
| Tryptophan | Trp | W |
| Tyrosine | Tyr | Y |
| Valine | Val | V |
| Any amino acid or as defined herein | Xaa | X |

For example, it is well known in the art that alterations in a gene which result in the production of a chemically equivalent amino acid at a given site, but do not affect the functional properties of the encoded protein are common. For the purposes of the present disclosure substitutions are defined as exchanges within one of the following five groups:

1. Small aliphatic, nonpolar or slightly polar residues: Ala, Ser, Thr (Pro, Gly);
2. Polar, negatively charged residues and their amides: Asp, Asn, Glu, Gln;
3. Polar, positively charged residues: His, Arg, Lys;
4. Large aliphatic, nonpolar residues: Met, Leu, Ile, Val (Cys); and
5. Large aromatic residues: Phe, Tyr, and Trp.

Thus, a codon for the amino acid alanine, a hydrophobic amino acid, may be substituted by a codon encoding another less hydrophobic residue (such as glycine) or a more hydrophobic residue (such as valine, leucine, or isoleucine). Similarly, changes which result in substitution of one negatively charged residue for another (such as aspartic acid for glutamic acid) or one positively charged residue for another (such as lysine for arginine) can also be expected to produce a functionally equivalent product. In many cases, nucleotide changes which result in alteration of the N-terminal and C-terminal portions of the protein molecule would also not be expected to alter the activity of the protein. Each of the proposed modifications is well within the routine skill in the art, as is determination of retention of biological activity of the encoded products.

As used herein, the term "codon optimized", as it refers to genes or coding regions of nucleic acid molecules for transformation of various hosts, refers to the alteration of codons in the gene or coding regions of

the nucleic acid molecules to reflect the typical codon usage of the host organism without altering the polypeptide for which the DNA codes.

As used herein, "synthetic genes" can be assembled from oligonucleotide building blocks that are chemically synthesized using procedures known to those skilled in the art. These building blocks are ligated and annealed to form gene segments that are then enzymatically assembled to construct the entire gene. "Chemically synthesized", as pertaining to a DNA sequence, means that the component nucleotides were assembled *in vitro*. Manual chemical synthesis of DNA may be accomplished using well-established procedures, or automated chemical synthesis can be performed using one of a number of commercially available machines. Accordingly, the genes can be tailored for optimal gene expression based on optimization of nucleotide sequences to reflect the codon bias of the host cell. The skilled artisan appreciates the likelihood of successful gene expression if codon usage is biased towards those codons favored by the host. Determination of preferred codons can be based on a survey of genes derived from the host cell where sequence information is available.

As used herein, "gene" refers to a nucleic acid molecule that expresses a specific protein, including regulatory sequences preceding (5' non-coding sequences) and following (3' non-coding sequences) the coding sequence. "Native gene" refers to a gene as found in nature with its own regulatory sequences. "Chimeric gene" refers to any gene that is not a native gene, comprising regulatory and coding sequences that are not found together in nature. Accordingly, a chimeric gene may comprise regulatory sequences and coding sequences that are derived from different sources, or regulatory sequences and coding sequences derived from the same source, but arranged in a manner different from that found in nature. "Endogenous gene" refers to a native gene in its natural location in the genome of an organism. A "foreign" gene refers to a gene not normally found in the host organism, but that is introduced into the host organism by gene transfer. Foreign genes can comprise native genes inserted into a non-native organism, or chimeric genes. A

“transgene” is a gene that has been introduced into the genome by a transformation procedure.

As used herein, “coding sequence” refers to a DNA sequence that codes for a specific amino acid sequence. “Suitable regulatory sequences” refer to nucleotide sequences located upstream (5' non-coding sequences), within, or downstream (3' non-coding sequences) of a coding sequence, and which influence the transcription, RNA processing or stability, or translation of the associated coding sequence. Regulatory sequences may include promoters, translation leader sequences, RNA processing site, effector binding sites, and stem-loop structures.

As used herein, the term “operably linked” refers to the association of nucleic acid sequences on a single nucleic acid molecule so that the function of one is affected by the other. For example, a promoter is operably linked with a coding sequence when it is capable of affecting the expression of that coding sequence, *i.e.*, the coding sequence is under the transcriptional control of the promoter. Coding sequences can be operably linked to regulatory sequences in sense or antisense orientation.

As used herein, the term “expression” refers to the transcription and stable accumulation of sense (mRNA) or antisense RNA derived from the nucleic acid molecule. Expression may also refer to translation of mRNA into a polypeptide.

As used herein, “transformation” refers to the transfer of a nucleic acid molecule into the genome of a host organism, resulting in genetically stable inheritance. In the present disclosure, the host cell’s genome includes chromosomal and extrachromosomal (*e.g.*, plasmid) genes. Host organisms containing the transformed nucleic acid molecules are referred to as “transgenic”, “recombinant” or “transformed” organisms.

As used herein, the term “sequence analysis software” refers to any computer algorithm or software program that is useful for the analysis of nucleotide or amino acid sequences. “Sequence analysis software” may be commercially available or independently developed. Typical sequence analysis software will include, but is not limited to, the GCG suite of programs (Wisconsin Package Version 9.0, Accelrys Software Corp., San Diego, CA), BLASTP, BLASTN, BLASTX (Altschul *et al.*, *J. Mol. Biol.*

215:403-410 (1990)), and DNASTAR (DNASTAR, Inc. 1228 S. Park St. Madison, WI 53715 USA), CLUSTALW (for example, version 1.83; Thompson *et al.*, *Nucleic Acids Research*, 22(22):4673-4680 (1994)), and the FASTA program incorporating the Smith-Waterman algorithm (W. R. Pearson, *Comput. Methods Genome Res.*, [Proc. Int. Symp.] (1994), Meeting Date 1992, 111-20. Editor(s): Suhai, Sandor. Publisher: Plenum, New York, NY), Vector NTI (Informax, Bethesda, MD) and Sequencher v. 4.05. Within the context of this application it will be understood that where sequence analysis software is used for analysis, that the results of the analysis will be based on the "default values" of the program referenced, unless otherwise specified. As used herein "default values" will mean any set of values or parameters set by the software manufacturer that originally load with the software when first initialized.

15 Structural and Functional Properties of the Soluble α -Glucan
Oligomer/polymer Composition

The present soluble α -glucan oligomer/polymer composition was prepared from sucrose (e.g., cane sugar) using one or more enzymatic processing aids that have essentially the same amino acid sequences as found in nature (or active truncations thereof) from microorganisms which having a long history of exposure to humans (microorganisms naturally found in the oral cavity or found in foods such a beer, fermented soybeans, etc.). The soluble oligomers/polymers have low viscosity (enabling use in a broad range of applications),

25 The present soluble α -glucan oligomer/polymer composition is characterized by the following combination of parameters:

- a. 25-35 α -(1,3) glycosidic linkages;
- b. 55-75% α -(1,6) glycosidic linkages;
- c. 5-15% α -(1,3,6) glycosidic linkages;
- 30 d. a weight average molecular weight of less than 5000 Daltons;
- e. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
- h. a solubility of at least 20% (w/w) in water at 25 °C; and

- i. a polydispersity index of less than 5.

In another embodiment, the present soluble α -glucan oligomer/polymer composition is characterized by

- 5 a. 25-35 α -(1,3) glycosidic linkages;
 b. 55-65% α -(1,6) glycosidic linkages; and
 c. 5-15% α -(1,3,6) glycosidic linkages.

In a further embodiment, the present soluble α -glucan oligomer/polymer composition is characterized by

- 10 a. 27-31 α -(1,3) glycosidic linkages;
 b. 57-61% α -(1,6) glycosidic linkages; and
 c. 7-11% α -(1,3,6) glycosidic linkages.

In another embodiment, in addition to the above mentioned glycosidic linkage content embodiments, the present soluble α -glucan oligomer/polymer composition further comprises less than 4%, preferably
15 less than 2 %, more preferably less than 1%, and most preferably less than 0.5 % α -(1,4) glycosidic linkages.

In another embodiment, in addition the above mentioned glycosidic linkage content embodiments, the present α -glucan oligomer/polymer composition comprises a weight average molecular weight (M_w) of less
20 than 5000 Daltons, preferably less than 2500 Daltons, more preferably between 500 and 2500 Daltons, and most preferably about 500 to about 2000 Daltons.

In another embodiment, in addition to any of the above features, the present α -glucan oligomer/polymer composition comprises a viscosity of
25 less than 250 centipoise (cP) (0.25 Pascal second (Pa·s)); preferably less than 10 centipoise (cP) (0.01 Pascal second (Pa·s)), preferably less than 7 cP (0.007 Pa·s), more preferably less than 5 cP (0.005 Pa·s), more preferably less than 4 cP (0.004 Pa·s), and most preferably less than 3 cP (0.003 Pa·s) at 12 wt% in water at 20 °C.

30 In addition to any of the above embodiments, the present soluble α -glucan oligomer/polymer composition has a solubility of at least 20 % (w/w), preferably at least 30%, 40%, 50%, 60%, or 70% in pH 7 water at 25 °C.

In another embodiment, the present soluble α -glucan oligomer/polymer composition comprises a number average molecular weight (Mn) between 400 and 2500 g/mol, preferably 1000 to 2000 g/mol.

5 Compositions Comprising α -Glucan Oligomer/Polymers and/or α -Glucan Ethers

Depending upon the desired application, the present α -glucan oligomer/polymer composition and/or derivatives thereof (such as the present α -glucan ethers) may be formulated (e.g., blended, mixed,
10 incorporated into, etc.) with one or more other materials and/or active ingredients suitable for use in laundry care, textile/fabric care, and/or personal care products. As such, the present disclosure includes compositions comprising the present glucan oligomer/polymer composition. The term "compositions comprising the present glucan
15 oligomer/polymer composition" in this context may include, for example, aqueous formulations comprising the present glucan oligomer/polymer, rheology modifying compositions, fabric treatment/care compositions, laundry care formulations/compositions, fabric softeners, personal care compositions (hair, skin and oral care), and the like.

20 The present glucan oligomer/polymer composition may be directed as an ingredient in a desired product or may be blended with one or more additional suitable ingredients (ingredients suitable for fabric care applications, laundry care applications, and/or personal care applications). As such, the present disclosure comprises a fabric care, laundry care, or
25 personal care composition comprising the present soluble α -glucan oligomer/polymer composition, the present α -glucan ethers, or a combination thereof. In one embodiment, the fabric care, laundry care or personal care composition comprises 0.01 to 99 wt % (dry solids basis), preferably 0.1 to 90 wt %, more preferably 1 to 90%, and most preferably 5
30 to 80 wt% of the glucan oligomer/polymer composition and/or the present α -glucan ether compounds.

In one embodiment, a fabric care composition is provided comprising:

- a. an α -glucan oligomer/polymer composition comprising:

- i. 25-35 α -(1,3) glycosidic linkages;
 - ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons;
 - v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - vi. a solubility of at least 20% (w/w) in water at 25 °C; and
 - vii. a polydispersity index of less than 5; and
- b. at least one additional fabric care ingredient.

In another embodiment, a laundry care composition is provided comprising:

- a) an α -glucan oligomer/polymer composition comprising:
- i. 25-35 α -(1,3) glycosidic linkages;
 - ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons ;
 - v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - vi. a solubility of at least 20% (w/w) in water at 25 °C; and
 - vii. a polydispersity index of less than 5; and
- b) at least one additional laundry care ingredient.

In another embodiment, an α -glucan ether derived from the present α -glucan oligomer/polymer composition is provided comprising:

- a. 25-35 α -(1,3) glycosidic linkages;
- b. 55-75% α -(1,6) glycosidic linkages;
- c. 5-15% α -(1,3,6) glycosidic linkages;
- d. a weight average molecular weight of less than 5000 Daltons;

- e. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - f. a solubility of at least 20% (w/w) in water at 25 °C; and
 - g. a polydispersity index of less than 5; wherein the
- 5 composition has a degree of substitution (DoS) with at least one organic group of about 0.05 to about 3.0.

10 In a further embodiment to anyany of the above embodiments, the glucan ether composition has a degree of substitution (DoS) with at least one organic group of about 0.05 to about 3.0.

In a further embodiment to anyany of the above embodiments, the glucan ether composition comprises at least one organic group is selected from the group consisting of carboxy alkyl group, hydroxy alkyl group, and alkyl group.

15 In a further embodiment to any of the above embodiments, the at least one organic group is selected from the group consisting of carboxymethyl, hydroxypropyl, dihydroxypropyl, hydroxyethyl, methyl, and ethyl group.

20 In a further embodiment to any of the above embodiments, the at least one organic group is a positively charged organic group.

In a further embodiment to any of the above embodiments, the glucan ether is a quaternary ammonium glucan ether.

In a further embodiment to any of the above embodiments, the glucan ether composition is a trimethylammonium hydroxypropyl glucan.

25 In a further embodiment to any of the above embodiments, an organic group may be an alkyl group such as a methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, or decyl group, for example.

In a further embodiment to any of the above embodiments, the organic group may be a substituted alkyl group in which there is a

30 substitution on one or more carbons of the alkyl group. The substitution(s) may be one or more hydroxyl, aldehyde, ketone, and/or carboxyl groups. For example, a substituted alkyl group may be a hydroxy alkyl group, dihydroxy alkyl group, or carboxy alkyl group.

Examples of suitable hydroxy alkyl groups are hydroxymethyl (-CH₂OH), hydroxyethyl (e.g., -CH₂CH₂OH, -CH(OH)CH₃), hydroxypropyl (e.g., -CH₂CH₂CH₂OH, -CH₂CH(OH)CH₃, -CH(OH)CH₂CH₃), hydroxybutyl and hydroxypentyl groups. Other examples include dihydroxy alkyl groups (diols) such as dihydroxymethyl, dihydroxyethyl (e.g., -CH(OH)CH₂OH),
5 dihydroxypropyl (e.g., -CH₂CH(OH)CH₂OH, -CH(OH)CH(OH)CH₃), dihydroxybutyl and dihydroxypentyl groups.

Examples of suitable carboxy alkyl groups are carboxymethyl (-CH₂COOH), carboxyethyl (e.g., -CH₂CH₂COOH, -CH(COOH)CH₃),
10 carboxypropyl (e.g., -CH₂CH₂CH₂COOH, -CH₂CH(COOH)CH₃, -CH(COOH)CH₂CH₃), carboxybutyl and carboxypentyl groups.

Alternatively still, one or more carbons of an alkyl group can have a substitution(s) with another alkyl group. Examples of such substituent alkyl groups are methyl, ethyl and propyl groups. To illustrate, an organic
15 group can be -CH(CH₃)CH₂CH₃ or -CH₂CH(CH₃)CH₃, for example, which are both propyl groups having a methyl substitution.

As should be clear from the above examples of various substituted alkyl groups, a substitution (e.g., hydroxy or carboxy group) on an alkyl group in certain embodiments may be bonded to the terminal carbon atom
20 of the alkyl group, where the terminal carbon group is opposite the terminus that is in ether linkage to a glucose monomeric unit in an α -glucan ether compound. An example of this terminal substitution is the hydroxypropyl group -CH₂CH₂CH₂OH. Alternatively, a substitution may be on an internal carbon atom of an alkyl group. An example on an internal
25 substitution is the hydroxypropyl group -CH₂CH(OH)CH₃. An alkyl group can have one or more substitutions, which may be the same (e.g., two hydroxyl groups [dihydroxy]) or different (e.g., a hydroxyl group and a carboxyl group).

In a further embodiment to any of the above embodiments, the α -
30 glucan ether compounds disclosed herein may contain one type of organic group. Examples of such compounds contain a carboxy alkyl group as the organic group (carboxyalkyl α -glucan, generically speaking). A specific non-limiting example of such a compound is carboxymethyl α -glucan.

In a further embodiment to any of the above embodiments, α -glucan ether compounds disclosed herein can contain two or more different types of organic groups. Examples of such compounds contain (i) two different alkyl groups as organic groups, (ii) an alkyl group and a hydroxy alkyl group as organic groups (alkyl hydroxyalkyl α -glucan, generically speaking), (iii) an alkyl group and a carboxy alkyl group as organic groups (alkyl carboxyalkyl α -glucan, generically speaking), (iv) a hydroxy alkyl group and a carboxy alkyl group as organic groups (hydroxyalkyl carboxyalkyl α -glucan, generically speaking), (v) two different hydroxy alkyl groups as organic groups, or (vi) two different carboxy alkyl groups as organic groups. Specific non-limiting examples of such compounds include ethyl hydroxyethyl α -glucan, hydroxyalkyl methyl α -glucan, carboxymethyl hydroxyethyl α -glucan, and carboxymethyl hydroxypropyl α -glucan.

In a further embodiment to any of the above embodiments, the organic group herein can alternatively be a positively charged organic group. As defined above, a positively charged organic group comprises a chain of one or more carbons having one or more hydrogens substituted with another atom or functional group, where one or more of the substitutions is with a positively charged group.

A positively charged group may be a substituted ammonium group, for example. Examples of substituted ammonium groups are primary, secondary, tertiary and quaternary ammonium groups. Structure I depicts a primary, secondary, tertiary or quaternary ammonium group, depending on the composition of R_2 , R_3 and R_4 in structure I. Each of R_2 , R_3 and R_4 in structure I independently represent a hydrogen atom or an alkyl, aryl, cycloalkyl, aralkyl, or alkaryl group. Alternatively, each of R_2 , R_3 and R_4 can independently represent a hydrogen atom or an alkyl group. An alkyl group can be a methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, or decyl group, for example. Where two or three of R_2 , R_3 and R_4 are an alkyl group, they can be the same or different alkyl groups.

A "primary ammonium α -glucan ether compound" herein can comprise a positively charged organic group having an ammonium group. In this example, the positively charged organic group comprises structure I

in which each of R₂, R₃ and R₄ is a hydrogen atom. A non-limiting example of such a positively charged organic group is represented by structure II when each of R₂, R₃ and R₄ is a hydrogen atom. An example of a primary ammonium α -glucan ether compound can be represented in shorthand as ammonium α -glucan ether. It would be understood that a first member (i.e., R₁) implied by "primary" in the above nomenclature is the chain of one or more carbons of the positively charged organic group that is ether-linked to a glucose monomer of α -glucan.

A "secondary ammonium α -glucan ether compound" herein can comprise a positively charged organic group having a monoalkylammonium group, for example. In this example, the positively charged organic group comprises structure I in which each of R₂ and R₃ is a hydrogen atom and R₄ is an alkyl group. A non-limiting example of such a positively charged organic group is represented by structure II when each of R₂ and R₃ is a hydrogen atom and R₄ is an alkyl group. An example of a secondary ammonium α -glucan ether compound can be represented in shorthand herein as monoalkylammonium α -glucan ether (e.g., monomethyl-, monoethyl-, monopropyl-, monobutyl-, monopentyl-, monohexyl-, monoheptyl-, monooctyl-, monononyl- or monodecyl-ammonium α -glucan ether). It would be understood that a second member (i.e., R₁) implied by "secondary" in the above nomenclature is the chain of one or more carbons of the positively charged organic group that is ether-linked to a glucose monomer of α -glucan.

A "tertiary ammonium α -glucan ether compound" herein can comprise a positively charged organic group having a dialkylammonium group, for example. In this example, the positively charged organic group comprises structure I in which R₂ is a hydrogen atom and each of R₃ and R₄ is an alkyl group. A non-limiting example of such a positively charged organic group is represented by structure II when R₂ is a hydrogen atom and each of R₃ and R₄ is an alkyl group. An example of a tertiary ammonium α -glucan ether compound can be represented in shorthand as dialkylammonium α -glucan ether (e.g., dimethyl-, diethyl-, dipropyl-, dibutyl-, dipentyl-, dihexyl-, diheptyl-, dioctyl-, dinonyl- or didecyl-ammonium α -glucan ether). It would be understood that a third member

(i.e., R₁) implied by “tertiary” in the above nomenclature is the chain of one or more carbons of the positively charged organic group that is ether-linked to a glucose monomer of α -glucan.

- A “quaternary ammonium α -glucan ether compound” herein can
- 5 comprise a positively charged organic group having a trialkylammonium group, for example. In this example, the positively charged organic group comprises structure I in which each of R₂, R₃ and R₄ is an alkyl group. A non-limiting example of such a positively charged organic group is represented by structure II when each of R₂, R₃ and R₄ is an alkyl group.
- 10 An example of a quaternary ammonium α -glucan ether compound can be represented in shorthand as trialkylammonium α -glucan ether (e.g., trimethyl-, triethyl-, tripropyl-, tributyl-, tripentyl-, trihexyl-, triheptyl-, trioctyl-, trinonyl- or tridecyl- ammonium α -glucan ether). It would be understood that a fourth member (i.e., R₁) implied by “quaternary” in the above
- 15 nomenclature is the chain of one or more carbons of the positively charged organic group that is ether-linked to a glucose monomer of α -glucan.

- Additional non-limiting examples of substituted ammonium groups that can serve as a positively charged group herein are represented in structure I when each of R₂, R₃ and R₄ independently represent a
- 20 hydrogen atom; an alkyl group such as a methyl, ethyl, or propyl group; an aryl group such as a phenyl or naphthyl group; an aralkyl group such as a benzyl group; an alkaryl group; or a cycloalkyl group. Each of R₂, R₃ and R₄ may further comprise an amino group or a hydroxyl group, for example.

- The nitrogen atom in a substituted ammonium group represented
- 25 by structure I is bonded to a chain of one or more carbons as comprised in a positively charged organic group. This chain of one or more carbons (“carbon chain”) is ether-linked to a glucose monomer of α -glucan, and may have one or more substitutions in addition to the substitution with the nitrogen atom of the substituted ammonium group. There can be 1, 2, 3,
- 30 4, 5, 6, 7, 8, 9 or 10 carbons, for example, in a carbon chain. To illustrate, the carbon chain of structure II is 3 carbon atoms in length.

Examples of a carbon chain of a positively charged organic group that do not have a substitution in addition to the substitution with a positively charged group include -CH₂-, -CH₂CH₂-, -CH₂CH₂CH₂-,

-CH₂CH₂CH₂CH₂- and -CH₂CH₂CH₂CH₂CH₂-. In each of these examples, the first carbon atom of the chain is ether-linked to a glucose monomer of α -glucan, and the last carbon atom of the chain is linked to a positively charged group. Where the positively charged group is a substituted ammonium group, the last carbon atom of the chain in each of these examples is represented by the C in structure I.

Where a carbon chain of a positively charged organic group has a substitution in addition to a substitution with a positively charged group, such additional substitution may be with one or more hydroxyl groups, oxygen atoms (thereby forming an aldehyde or ketone group), alkyl groups (e.g., methyl, ethyl, propyl, butyl), and/or additional positively charged groups. A positively charged group is typically bonded to the terminal carbon atom of the carbon chain.

Examples of a carbon chain of a positively charged organic group having one or more substitutions with a hydroxyl group include hydroxyalkyl (e.g., hydroxyethyl, hydroxypropyl, hydroxybutyl, hydroxypentyl) groups and dihydroxyalkyl (e.g., dihydroxyethyl, dihydroxypropyl, dihydroxybutyl, dihydroxypentyl) groups. Examples of hydroxyalkyl and dihydroxyalkyl (diol) carbon chains include -CH(OH)-, -CH(OH)CH₂-, -C(OH)₂CH₂-, -CH₂CH(OH)CH₂-, -CH(OH)CH₂CH₂-, -CH(OH)CH(OH)CH₂-, -CH₂CH₂CH(OH)CH₂-, -CH₂CH(OH)CH₂CH₂-, -CH(OH)CH₂CH₂CH₂-, -CH₂CH(OH)CH(OH)CH₂-, -CH(OH)CH(OH)CH₂CH₂- and -CH(OH)CH₂CH(OH)CH₂-. In each of these examples, the first carbon atom of the chain is ether-linked to a glucose monomer of the present α -glucan, and the last carbon atom of the chain is linked to a positively charged group. Where the positively charged group is a substituted ammonium group, the last carbon atom of the chain in each of these examples is represented by the C in structure I.

Examples of a carbon chain of a positively charged organic group having one or more substitutions with an alkyl group include chains with one or more substituent methyl, ethyl and/or propyl groups. Examples of methylalkyl groups include -CH(CH₃)CH₂CH₂- and -CH₂CH(CH₃)CH₂-, which are both propyl groups having a methyl substitution. In each of these examples, the first carbon atom of the chain is ether-linked to a

glucose monomer of the present α -glucan, and the last carbon atom of the chain is linked to a positively charged group. Where the positively charged group is a substituted ammonium group, the last carbon atom of the chain in each of these examples is represented by the C in structure I.

- 5 In a further embodiment to any of the above embodiments, the α -glucan ether compounds herein may contain one type of positively charged organic group. For example, one or more positively charged organic groups ether-linked to the glucose monomer of α -glucan may be trimethylammonium hydroxypropyl groups (structure II). Alternatively, α -glucan ether compounds disclosed herein can contain two or more
10 different types of positively charged organic groups.

- In a further embodiment to any of the above embodiments, α -glucan ether compounds herein can comprise at least one nonionic organic group and at least one anionic group, for example. As another
15 example, α -glucan ether compounds herein can comprise at least one nonionic organic group and at least one positively charged organic group.

- In a further embodiment to any of the above embodiments, α -glucan ether compounds may be derived from any of the present α -glucan oligomers/polymers disclosed herein. For example, the α -glucan ether
20 compound can be produced by ether-derivatizing the present α -glucan oligomers/polymers using an etherification reaction as disclosed herein.

- In certain embodiments, a composition comprising an α -glucan ether compound can be a hydrocolloid or aqueous solution having a viscosity of at least about 10 cPs. Alternatively, such a hydrocolloid or
25 aqueous solution has a viscosity of at least about 100, 250, 500, 750, 1000, 1250, 1500, 1750, 2000, 2250, 2500, 3000, 3500, or 4000 cPs (or any integer between 100 and 4000 cPs), for example.

- Viscosity can be measured with the hydrocolloid or aqueous solution at any temperature between about 3 °C to about 110 °C (or any
30 integer between 3 and 110 °C). Alternatively, viscosity can be measured at a temperature between about 4 °C to 30 °C, or about 20 °C to 25 °C. Viscosity can be measured at atmospheric pressure (about 760 torr) or any other higher or lower pressure.

The viscosity of a hydrocolloid or aqueous solution disclosed herein can be measured using a viscometer or rheometer, or using any other means known in the art. It would be understood by those skilled in the art that a viscometer or rheometer can be used to measure the viscosity of those hydrocolloids and aqueous solutions that exhibit shear thinning behavior or shear thickening behavior (i.e., liquids with viscosities that vary with flow conditions). The viscosity of such embodiments can be measured at a rotational shear rate of about 10 to 1000 rpm (revolutions per minute) (or any integer between 10 and 1000 rpm), for example. Alternatively, viscosity can be measured at a rotational shear rate of about 10, 60, 150, 250, or 600 rpm.

The pH of a hydrocolloid or aqueous solution disclosed herein can be between about 2.0 to about 12.0. Alternatively, pH can be about 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0; or between 5.0 to about 12.0; or between about 4.0 and 8.0; or between about 5.0 and 8.0.

An aqueous composition herein such as a hydrocolloid or aqueous solution can comprise a solvent having at least about 20 wt% water. In other embodiments, a solvent is at least about 30, 40, 50, 60, 70, 80, 90, or 100 wt% water (or any integer value between 20 and 100 wt%), for example.

In a further embodiment to any of the above embodiments, the α -glucan ether compound disclosed herein can be present in a hydrocolloid or aqueous solution at a weight percentage (wt%) of at least about 0.01%, 0.05%, 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6%, 0.7%, 0.8%, 0.9%, 1.0%, 1.2%, 1.4%, 1.6%, 1.8%, 2.0%, 2.5%, 3.0%, 3.5%, 4.0%, 4.5%, 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 15%, 16%, 17%, 18%, 19%, 20%, 21%, 22%, 23%, 24%, 25%, 26%, 27%, 28%, 29%, or 30%, for example.

In a further embodiment to any of the above embodiments, the hydrocolloid or aqueous solution herein can comprise other components in addition to one or more α -glucan ether compounds. For example, the hydrocolloid or aqueous solution can comprise one or more salts such as a sodium salt (e.g., NaCl, Na₂SO₄). Other non-limiting examples of salts include those having (i) an aluminum, ammonium, barium, calcium,

chromium (II or III), copper (I or II), iron (II or III), hydrogen, lead (II), lithium, magnesium, manganese (II or III), mercury (I or II), potassium, silver, sodium strontium, tin (II or IV), or zinc cation, and (ii) an acetate, borate, bromate, bromide, carbonate, chlorate, chloride, chlorite, chromate, cyanamide, cyanide, dichromate, dihydrogen phosphate, ferricyanide, ferrocyanide, fluoride, hydrogen carbonate, hydrogen phosphate, hydrogen sulfate, hydrogen sulfide, hydrogen sulfite, hydride, hydroxide, hypochlorite, iodate, iodide, nitrate, nitride, nitrite, oxalate, oxide, perchlorate, permanganate, peroxide, phosphate, phosphide, phosphite, silicate, stannate, stannite, sulfate, sulfide, sulfite, tartrate, or thiocyanate anion. Thus, any salt having a cation from (i) above and an anion from (ii) above can be in a hydrocolloid or aqueous solution, for example. A salt can be present in a hydrocolloid or aqueous solution at a wt% of about .01% to about 10.00% (or any hundredth increment between .01% and 10.00%), for example.

In a further embodiment to any of the above embodiments, those skilled in the art would understand that in certain embodiments, the α -glucan ether compound can be in an anionic form in a hydrocolloid or aqueous solution. Examples may include those α -glucan ether compounds having an organic group comprising an alkyl group substituted with a carboxyl group. Carboxyl (COOH) groups in a carboxyalkyl α -glucan ether compound can convert to carboxylate (COO⁻) groups in aqueous conditions. Such anionic groups can interact with salt cations such as any of those listed above in (i) (e.g., potassium, sodium, or lithium cation). Thus, an α -glucan ether compound can be a sodium carboxyalkyl α -glucan ether (e.g., sodium carboxymethyl α -glucan), potassium carboxyalkyl α -glucan ether (e.g., potassium carboxymethyl α -glucan), or lithium carboxyalkyl α -glucan ether (e.g., lithium carboxymethyl α -glucan), for example.

In alternative embodiments to any of the above embodiments, a composition comprising the α -glucan ether compound herein can be non-aqueous (e.g., a dry composition). Examples of such embodiments include powders, granules, microcapsules, flakes, or any other form of particulate matter. Other examples include larger compositions such as

pellets, bars, kernels, beads, tablets, sticks, or other agglomerates. A non-aqueous or dry composition herein typically has less than 3, 2, 1, 0.5, or 0.1 wt% water comprised therein.

In certain embodiments the α -glucan ether compound may be crosslinked using any means known in the art. Such crosslinks may be borate crosslinks, where the borate is from any boron-containing compound (e.g., boric acid, diborates, tetraborates, pentaborates, polymeric compounds such as Polybor®, polymeric compounds of boric acid, alkali borates), for example. Alternatively, crosslinks can be provided with polyvalent metals such as titanium or zirconium. Titanium crosslinks may be provided, for example, using titanium IV-containing compounds such as titanium ammonium lactate, titanium triethanolamine, titanium acetylacetonate, and polyhydroxy complexes of titanium. Zirconium crosslinks can be provided using zirconium IV-containing compounds such as zirconium lactate, zirconium carbonate, zirconium acetylacetonate, zirconium triethanolamine, zirconium diisopropylamine lactate and polyhydroxy complexes of zirconium, for example. Alternatively still, crosslinks can be provided with any crosslinking agent described in U.S. Patent Nos. 4462917, 4464270, 4477360 and 4799550, which are all incorporated herein by reference. A crosslinking agent (e.g., borate) may be present in an aqueous composition herein at a concentration of about 0.2% to 20 wt%, or about 0.1, 0.2, 0.3, 0.4, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, or 20 wt%, for example.

It is believed that an α -glucan ether compound disclosed herein that is crosslinked typically has a higher viscosity in an aqueous solution compared to its non-crosslinked counterpart. In addition, it is believed that a crosslinked α -glucan ether compound can have increased shear thickening behavior compared to its non-crosslinked counterpart.

In a further embodiment to any of the above embodiments, a composition herein (fabric care, laundry care, personal care, etc.) may optionally contain one or more active enzymes. Non-limiting examples of suitable enzymes include proteases, cellulases, hemicellulases, peroxidases, lipolytic enzymes (e.g., metallolipolytic enzymes), xylanases, lipases, phospholipases, esterases (e.g., arylesterase, polyesterase),

perhydrolases, cutinases, pectinases, pectate lyases, mannanases, keratinases, reductases, oxidases (e.g., choline oxidase), phenoloxidases, lipoxygenases, ligninases, pullulanases, tannases, pentosanases, malanases, beta-glucanases, arabinosidases, hyaluronidases, chondroitinases, laccases, metalloproteinases, amadoriases, glucoamylases, arabinofuranosidases, phytases, isomerases, transferases and amylases. If an enzyme(s) is included, it may be comprised in a composition herein at about 0.0001-0.1 wt% (e.g., 0.01-0.03 wt%) active enzyme (e.g., calculated as pure enzyme protein), for example.

10 A cellulase herein can have endocellulase activity (EC 3.2.1.4), exocellulase activity (EC 3.2.1.91), or cellobiase activity (EC 3.2.1.21). A cellulase herein is an "active cellulase" having activity under suitable conditions for maintaining cellulase activity; it is within the skill of the art to determine such suitable conditions. Besides being able to degrade
15 cellulose, a cellulase in certain embodiments can also degrade cellulose ether derivatives such as carboxymethyl cellulose. Examples of cellulose ether derivatives which are expected to not be stable to cellulase are disclosed in U.S. Patent Nos. 7012053, 7056880, 6579840, 7534759 and 7576048.

20 A cellulase herein may be derived from any microbial source, such as a bacteria or fungus. Chemically-modified cellulases or protein-engineered mutant cellulases are included. Suitable cellulases include, but are not limited to, cellulases from the genera *Bacillus*, *Pseudomonas*, *Streptomyces*, *Trichoderma*, *Humicola*, *Fusarium*, *Thielavia* and
25 *Acremonium*. As other examples, a cellulase may be derived from *Humicola insolens*, *Myceliophthora thermophila* or *Fusarium oxysporum*; these and other cellulases are disclosed in U.S. Patent Nos. 4435307, 5648263, 5691178, 5776757 and 7604974, which are all incorporated herein by reference. Exemplary *Trichoderma reesei* cellulases are
30 disclosed in U.S. Patent Nos. 4689297, 5814501, 5324649, and International Patent Appl. Publ. Nos. WO92/06221 and WO92/06165, all of which are incorporated herein by reference. Exemplary *Bacillus* cellulases are disclosed in U.S. Patent No. 6562612, which is incorporated herein by reference. A cellulase, such as any of the foregoing, preferably

is in a mature form lacking an N-terminal signal peptide. Commercially available cellulases useful herein include CELLUZYME® and CAREZYME® (Novozymes A/S); CLAZINASE® and PURADAX® HA (DuPont Industrial Biosciences), and KAC-500(B)® (Kao Corporation).

5 Alternatively, a cellulase herein may be produced by any means known in the art, such as described in U.S. Patent Nos. 4435307, 5776757 and 7604974, which are incorporated herein by reference. For example, a cellulase may be produced recombinantly in a heterologous expression system, such as a microbial or fungal heterologous expression
10 system. Examples of heterologous expression systems include bacterial (e.g., *E. coli*, *Bacillus* sp.) and eukaryotic systems. Eukaryotic systems can employ yeast (e.g., *Pichia* sp., *Saccharomyces* sp.) or fungal (e.g., *Trichoderma* sp. such as *T. reesei*, *Aspergillus* species such as *A. niger*) expression systems, for example.

15 One or more cellulases can be directly added as an ingredient when preparing a composition disclosed herein. Alternatively, one or more cellulases can be indirectly (inadvertently) provided in the disclosed composition. For example, cellulase can be provided in a composition herein by virtue of being present in a non-cellulase enzyme preparation
20 used for preparing a composition. Cellulase in compositions in which cellulase is indirectly provided thereto can be present at about 0.1-10 ppb (e.g., less than 1 ppm), for example. A contemplated benefit of a composition herein, by virtue of employing a poly alpha-1,3-1,6-glucan ether compound instead of a cellulose ether compound, is that non-
25 cellulase enzyme preparations that might have background cellulase activity can be used without concern that the desired effects of the glucan ether will be negated by the background cellulase activity.

 A cellulase in certain embodiments can be thermostable. Cellulase thermostability refers to the ability of the enzyme to retain activity after
30 exposure to an elevated temperature (e.g. about 60-70 °C) for a period of time (e.g., about 30-60 minutes). The thermostability of a cellulase can be measured by its half-life ($t_{1/2}$) given in minutes, hours, or days, during which time period half the cellulase activity is lost under defined conditions.

A cellulase in certain embodiments can be stable to a wide range of pH values (e.g. neutral or alkaline pH such as pH of ~7.0 to ~11.0). Such enzymes can remain stable for a predetermined period of time (e.g., at least about 15 min., 30 min., or 1 hour) under such pH conditions.

5 At least one, two, or more cellulases may be included in the composition. The total amount of cellulase in a composition herein typically is an amount that is suitable for the purpose of using cellulase in the composition (an "effective amount"). For example, an effective amount of cellulase in a composition intended for improving the feel and/or
10 appearance of a cellulose-containing fabric is an amount that produces measurable improvements in the feel of the fabric (e.g., improving fabric smoothness and/or appearance, removing pills and fibrils which tend to reduce fabric appearance sharpness). As another example, an effective amount of cellulase in a fabric stonewashing composition herein is that
15 amount which will provide the desired effect (e.g., to produce a worn and faded look in seams and on fabric panels). The amount of cellulase in a composition herein can also depend on the process parameters in which the composition is employed (e.g., equipment, temperature, time, and the like) and cellulase activity, for example. The effective concentration of
20 cellulase in an aqueous composition in which a fabric is treated can be readily determined by a skilled artisan. In fabric care processes, cellulase can be present in an aqueous composition (e.g., wash liquor) in which a fabric is treated in a concentration that is minimally about 0.01-0.1 ppm total cellulase protein, or about 0.1-10 ppb total cellulase protein (e.g., less
25 than 1 ppm), to maximally about 100, 200, 500, 1000, 2000, 3000, 4000, or 5000 ppm total cellulase protein, for example.

 In a further embodiment to any of the above embodiments, the α -glucan oligomer/polymers and/or the present α -glucan ethers (derived from the present α -glucan oligomer/polymers) are mostly or completely
30 stable (resistant) to being degraded by cellulase. For example, the percent degradation of the present α -glucan oligomers/polymers and/or α -glucan ether compounds by one or more cellulases is less than 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, or 1%, or is 0%. Such percent degradation can be determined, for example, by comparing the molecular weight of

polymer before and after treatment with a cellulase for a period of time (e.g., ~24 hours).

In a further embodiment to any of the above embodiments, hydrocolloids and aqueous solutions in certain embodiments are believed to have either shear thinning behavior or shear thickening behavior. Shear thinning behavior is observed as a decrease in viscosity of the hydrocolloid or aqueous solution as shear rate increases, whereas shear thickening behavior is observed as an increase in viscosity of the hydrocolloid or aqueous solution as shear rate increases. Modification of the shear thinning behavior or shear thickening behavior of an aqueous solution herein is due to the admixture of the α -glucan ether to the aqueous composition. Thus, one or more α -glucan ether compounds can be added to an aqueous composition to modify its rheological profile (i.e., the flow properties of the aqueous liquid, solution, or mixture are modified). Also, one or more α -glucan ether compounds can be added to an aqueous composition to modify its viscosity.

The rheological properties of hydrocolloids and aqueous solutions can be observed by measuring viscosity over an increasing rotational shear rate (e.g., from about 10 rpm to about 250 rpm). For example, shear thinning behavior of a hydrocolloid or aqueous solution disclosed herein can be observed as a decrease in viscosity (cPs) by at least about 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, or 95% (or any integer between 5% and 95%) as the rotational shear rate increases from about 10 rpm to 60 rpm, 10 rpm to 150 rpm, 10 rpm to 250 rpm, 60 rpm to 150 rpm, 60 rpm to 250 rpm, or 150 rpm to 250 rpm. As another example, shear thickening behavior of a hydrocolloid or aqueous solution disclosed herein can be observed as an increase in viscosity (cPs) by at least about 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 100%, 125%, 150%, 175%, or 200% (or any integer between 5% and 200%) as the rotational shear rate increases from about 10 rpm to 60 rpm, 10 rpm to 150 rpm, 10 rpm to 250 rpm, 60 rpm to 150 rpm, 60 rpm to 250 rpm, or 150 rpm to 250 rpm.

A hydrocolloid or aqueous solution disclosed herein can be in the form of, and/or comprised in, a textile care product, a laundry care product, a personal care product, a pharmaceutical product, or industrial product.

5 The present α -glucan oligomers/polymers and/or the present α -glucan ether compounds can be used as thickening agents and/or dispersion agents in each of these products. Such a thickening agent may be used in conjunction with one or more other types of thickening agents if desired, such as those disclosed in U.S. Patent No. 8541041, the disclosure of which is incorporated herein by reference in its entirety.

10 A household and/or industrial product herein can be in the form of drywall tape-joint compounds; mortars; grouts; cement plasters; spray plasters; cement stucco; adhesives; pastes; wall/ceiling texturizers; binders and processing aids for tape casting, extrusion forming, injection molding and ceramics; spray adherents and suspending/dispersing aids
15 for pesticides, herbicides, and fertilizers; fabric care products such as fabric softeners and laundry detergents; hard surface cleaners; air fresheners; polymer emulsions; gels such as water-based gels; surfactant solutions; paints such as water-based paints; protective coatings; adhesives; sealants and caulks; inks such as water-based ink; metal-
20 working fluids; emulsion-based metal cleaning fluids used in electroplating, phosphatizing, galvanizing and/or general metal cleaning operations; hydraulic fluids (e.g., those used for fracking in downhole operations); and aqueous mineral slurries, for example.

In a further embodiment to any of the above embodiments,
25 compositions disclosed herein can be in the form of a fabric care composition. A fabric care composition herein can be used for hand wash, machine wash and/or other purposes such as soaking and/or pretreatment of fabrics, for example. A fabric care composition may take the form of, for example, a laundry detergent; fabric conditioner; any wash-, rinse-, or
30 dryer-added product; unit dose or spray. Fabric care compositions in a liquid form may be in the form of an aqueous composition as disclosed herein. In other aspects, a fabric care composition can be in a dry form such as a granular detergent or dryer-added fabric softener sheet. Other non-limiting examples of fabric care compositions herein include: granular

or powder-form all-purpose or heavy-duty washing agents; liquid, gel or paste-form all-purpose or heavy-duty washing agents; liquid or dry fine-fabric (e.g. delicates) detergents; cleaning auxiliaries such as bleach additives, "stain-stick", or pre-treatments; substrate-laden products such as dry and wetted wipes, pads, or sponges; sprays and mists.

A detergent composition herein may be in any useful form, e.g., as powders, granules, pastes, bars, unit dose, or liquid. A liquid detergent may be aqueous, typically containing up to about 70 wt% of water and 0 wt% to about 30 wt% of organic solvent. It may also be in the form of a compact gel type containing only about 30 wt% water.

A detergent composition herein typically comprises one or more surfactants, wherein the surfactant is selected from nonionic surfactants, anionic surfactants, cationic surfactants, ampholytic surfactants, zwitterionic surfactants, semi-polar nonionic surfactants and mixtures thereof. In some embodiments, the surfactant is present at a level of from about 0.1% to about 60%, while in alternative embodiments the level is from about 1% to about 50%, while in still further embodiments the level is from about 5% to about 40%, by weight of the cleaning composition. A detergent will usually contain 0 wt% to about 50 wt% of an anionic surfactant such as linear alkylbenzenesulfonate (LAS), alpha-olefinsulfonate (AOS), alkyl sulfate (fatty alcohol sulfate) (AS), alcohol ethoxysulfate (AEOS or AES), secondary alkanesulfonates (SAS), alpha-sulfo fatty acid methyl esters, alkyl- or alkenylsuccinic acid, or soap. In addition, a detergent composition may optionally contain 0 wt% to about 40 wt% of a nonionic surfactant such as alcohol ethoxylate (AEO or AE), carboxylated alcohol ethoxylates, nonylphenol ethoxylate, alkylpolyglycoside, alkyldimethylamineoxide, ethoxylated fatty acid monoethanolamide, fatty acid monoethanolamide, or polyhydroxy alkyl fatty acid amide (as described for example in WO92/06154, which is incorporated herein by reference).

A detergent composition herein typically comprises one or more detergent builders or builder systems. In some embodiments incorporating at least one builder, the cleaning compositions comprise at least about 1%, from about 3% to about 60% or even from about 5% to about 40%

builder by weight of the cleaning composition. Builders include, but are not limited to, the alkali metal, ammonium and alkanolammonium salts of polyphosphates, alkali metal silicates, alkaline earth and alkali metal carbonates, aluminosilicates, polycarboxylate compounds, ether

5 hydroxypolycarboxylates, copolymers of maleic anhydride with ethylene or vinyl methyl ether, 1, 3, 5-trihydroxy benzene-2, 4, 6-trisulphonic acid, and carboxymethyloxysuccinic acid, the various alkali metal, ammonium and substituted ammonium salts of polyacetic acids such as ethylenediamine tetraacetic acid and nitrilotriacetic acid, as well as polycarboxylates such

10 as mellitic acid, succinic acid, citric acid, oxydisuccinic acid, polymaleic acid, benzene 1,3,5-tricarboxylic acid, carboxymethyloxysuccinic acid, and soluble salts thereof. Indeed, it is contemplated that any suitable builder will find use in various embodiments of the present disclosure. Examples of a detergent builder or complexing agent include zeolite, diphosphate,

15 triphosphate, phosphonate, citrate, nitrilotriacetic acid (NTA), ethylenediaminetetraacetic acid (EDTA), diethylenetriaminepentaacetic acid (DTMPA), alkyl- or alkenylsuccinic acid, soluble silicates or layered silicates (e.g., SKS-6 from Hoechst). A detergent may also be unbuilt, i.e., essentially free of detergent builder.

20 In some embodiments, the builders form water-soluble hardness ion complexes (e.g., sequestering builders), such as citrates and polyphosphates (e.g., sodium tripolyphosphate and sodium tripolyphosphate hexahydrate, potassium tripolyphosphate, and mixed sodium and potassium tripolyphosphate, etc.). It is contemplated that any

25 suitable builder will find use in the present disclosure, including those known in the art (See e.g., EP 2 100 949).

In some embodiments, builders for use herein include phosphate builders and non-phosphate builders. In some embodiments, the builder is a phosphate builder. In some embodiments, the builder is a non-

30 phosphate builder. If present, builders are used in a level of from 0.1% to 80%, or from 5 to 60%, or from 10 to 50% by weight of the composition. In some embodiments the product comprises a mixture of phosphate and non-phosphate builders. Suitable phosphate builders include mono-phosphates, di-phosphates, tri-polyphosphates or oligomeric-

polyphosphates, including the alkali metal salts of these compounds, including the sodium salts. In some embodiments, a builder can be sodium tripolyphosphate (STPP). Additionally, the composition can comprise carbonate and/or citrate, preferably citrate that helps to achieve a neutral pH composition. Other suitable non-phosphate builders include homopolymers and copolymers of polycarboxylic acids and their partially or completely neutralized salts, monomeric polycarboxylic acids and hydroxycarboxylic acids and their salts. In some embodiments, salts of the above mentioned compounds include the ammonium and/or alkali metal salts, i.e. the lithium, sodium, and potassium salts, including sodium salts. Suitable polycarboxylic acids include acyclic, alicyclic, hetero-cyclic and aromatic carboxylic acids, wherein in some embodiments, they can contain at least two carboxyl groups which are in each case separated from one another by, in some instances, no more than two carbon atoms.

A detergent composition herein can comprise at least one chelating agent. Suitable chelating agents include, but are not limited to copper, iron and/or manganese chelating agents and mixtures thereof. In embodiments in which at least one chelating agent is used, the cleaning compositions comprise from about 0.1% to about 15% or even from about 3.0% to about 10% chelating agent by weight of the subject cleaning composition.

A detergent composition herein can comprise at least one deposition aid. Suitable deposition aids include, but are not limited to, polyethylene glycol, polypropylene glycol, polycarboxylate, soil release polymers such as polyterephthalic acid, clays such as kaolinite, montmorillonite, atapulgite, illite, bentonite, halloysite, and mixtures thereof.

A detergent composition herein can comprise one or more dye transfer inhibiting agents. Suitable polymeric dye transfer inhibiting agents include, but are not limited to, polyvinylpyrrolidone polymers, polyamine N-oxide polymers, copolymers of N-vinylpyrrolidone and N-vinylimidazole, polyvinylloxazolidones and polyvinylimidazoles or mixtures thereof. Additional dye transfer inhibiting agents include manganese phthalocyanine, peroxidases, polyvinylpyrrolidone polymers, polyamine N-oxide polymers, copolymers of N-vinylpyrrolidone and N-vinylimidazole,

polyvinylloxazolidones and polyvinylimidazoles and/or mixtures thereof; chelating agents examples of which include ethylene-diamine-tetraacetic acid (EDTA); diethylene triamine penta methylene phosphonic acid (DTPMP); hydroxy-ethane diphosphonic acid (HEDP); ethylenediamine

5 N,N'-disuccinic acid (EDDS); methyl glycine diacetic acid (MGDA); diethylene triamine penta acetic acid (DTPA); propylene diamine tetracetic acid (PDT A); 2-hydroxypyridine-N-oxide (HPNO); or methyl glycine diacetic acid (MGDA); glutamic acid N,N-diacetic acid (N,N-dicarboxymethyl glutamic acid tetrasodium salt (GLDA); nitrilotriacetic acid

10 (NTA); 4,5-dihydroxy-m-benzenedisulfonic acid; citric acid and any salts thereof; N-hydroxyethylethylenediaminetri-acetic acid (HEDTA), triethylenetetraaminehexaacetic acid (TTHA), N-hydroxyethyliminodiacetic acid (HEIDA), dihydroxyethylglycine (DHEG), ethylenediaminetetrapropionic acid (EDTP) and derivatives thereof, which

15 can be used alone or in combination with any of the above. In embodiments in which at least one dye transfer inhibiting agent is used, the cleaning compositions comprise from about 0.0001% to about 10%, from about 0.01% to about 5%, or even from about 0.1% to about 3% by weight of the cleaning composition.

20 A detergent composition herein can comprise silicates. In some such embodiments, sodium silicates (e.g., sodium disilicate, sodium metasilicate, and crystalline phyllosilicates) find use. In some embodiments, silicates are present at a level of from about 1% to about 20%. In some embodiments, silicates are present at a level of from about

25 5% to about 15% by weight of the composition.

A detergent composition herein can comprise dispersants. Suitable water-soluble organic materials include, but are not limited to the homo- or co-polymeric acids or their salts, in which the polycarboxylic acid comprises at least two carboxyl radicals separated from each other by not

30 more than two carbon atoms.

Any cellulase disclosed above is contemplated for use in the disclosed detergent compositions. Suitable cellulases include, but are not limited to *Humicola insolens* cellulases (See e.g., U.S. Pat. No. 4,435,307). Exemplary cellulases contemplated for such use are those

having color care benefit for a textile. Examples of cellulases that provide a color care benefit are disclosed in EP0495257, EP0531372, EP531315, WO96/11262, WO96/29397, WO94/07998; WO98/12307; WO95/24471, WO98/08940, and U.S. Patent Nos. 5457046, 5686593 and 5763254, all
5 of which are incorporated herein by reference. Examples of commercially available cellulases useful in a detergent include CELLUSOFT®, CELLUCLEAN®, CELLUZYME®, and CAREZYME® (Novo Nordisk A/S and Novozymes A/S); CLAZINASE®, PURADAX HA®, and REVITALENZ™ (DuPont Industrial Biosciences); BIOTOUCH® (AB
10 Enzymes); and KAC-500(B)™ (Kao Corporation). Additional cellulases are disclosed in, e.g., US7595182, US8569033, US7138263, US3844890, US4435307, US4435307, and GB2095275.

A detergent composition herein may additionally comprise one or more other enzymes in addition to at least one cellulase. Examples of
15 other enzymes include proteases, cellulases, hemicellulases, peroxidases, lipolytic enzymes (e.g., metallolipolytic enzymes), xylanases, lipases, phospholipases, esterases (e.g., arylesterase, polyesterase), perhydrolases, cutinases, pectinases, pectate lyases, mannanases, keratinases, reductases, oxidases (e.g., choline oxidase, phenoloxidase),
20 phenoloxidases, lipxygenases, ligninases, pullulanases, tannases, pentosanases, malanases, beta-glucanases, arabinosidases, hyaluronidases, chondroitinases, laccases, metalloproteinases, amadoriases, glucoamylases, alpha-amylases, beta-amylases, galactosidases, galactanases, catalases, carageenases, hyaluronidases,
25 keratinases, lactases, ligninases, peroxidases, phosphatases, polygalacturonases, pullulanases, rhamnogalactouronases, tannases, transglutaminases, xyloglucanases, xylosidases, metalloproteases, arabinofuranosidases, phytases, isomerases, transferases and/or amylases in any combination.

30 In some embodiments, the detergent compositions can comprise one or more enzymes, each at a level from about 0.00001 % to about 10% by weight of the composition and the balance of cleaning adjunct materials by weight of composition. In some other embodiments, the detergent compositions also comprise each enzyme at a level of about 0.0001 % to

about 10%, about 0.001% to about 5%, about 0.001% to about 2%, about 0.005% to about 0.5% enzyme by weight of the composition.

Suitable proteases include those of animal, vegetable or microbial origin. In some embodiments, microbial proteases are used. In some
5 embodiments, chemically or genetically modified mutants are included. In
some embodiments, the protease is a serine protease, preferably an
alkaline microbial protease or a trypsin-like protease. Examples of alkaline
proteases include subtilisins, especially those derived from *Bacillus* (e.g.,
subtilisin, lentus, amyloliquefaciens, subtilisin Carlsberg, subtilisin 309,
10 subtilisin 147 and subtilisin 168). Additional examples include those
mutant proteases described in U.S. Pat. Nos. RE 34,606, 5,955,340,
5,700,676, 6,312,936, and 6,482,628, all of which are incorporated herein
by reference. Additional protease examples include, but are not limited to
trypsin (e.g., of porcine or bovine origin), and the *Fusarium* protease
15 described in WO 89/06270. In some embodiments, commercially
available protease enzymes that find use in the present disclosure include,
but are not limited to MAXATASE®, MAXACAL™, MAXAPEM™,
OPTICLEAN®, OPTIMASE®, PROPERASE®, PURAFECT®,
PURAFECT® OXP, PURAMAX™, EXCELLASE™, PREFERENZ™
20 proteases (e.g. P100, P110, P280), EFFECTENZ™ proteases (e.g.
P1000, P1050, P2000), EXCELLENZ™ proteases (e.g. P1000),
ULTIMASE®, and PURAFAST™ (Genencor); ALCALASE®, SAVINASE®,
PRIMASE®, DURAZYM™, POLARZYME®, OVOZYME®, KANNASE®,
LIQUANASE®, NEUTRASE®, RELEASE® and ESPERASE®
25 (Novozymes); BLAP™ and BLAP™ variants (Henkel
Kommanditgesellschaft auf Aktien, Duesseldorf, Germany), and KAP (*B.*
alkalophilus subtilisin; Kao Corp., Tokyo, Japan). Various proteases are
described in WO95/23221, WO 92/21760, WO 09/149200, WO
09/149144, WO 09/149145, WO 11/072099, WO 10/056640, WO
30 10/056653, WO 11/140364, WO 12/151534, U.S. Pat. Publ. No.
2008/0090747, and U.S. Pat. Nos. 5,801,039, 5,340,735, 5,500,364,
5,855,625, US RE 34,606, 5,955,340, 5,700,676, 6,312,936, 6,482,628,
8,530,219, and various other patents. In some further embodiments,
neutral metalloproteases find use in the present disclosure, including but

not limited to the neutral metalloproteases described in WO1999014341, WO1999033960, WO1999014342, WO1999034003, WO2007044993, WO2009058303, WO2009058661. Exemplary metalloproteases include nprE, the recombinant form of neutral metalloprotease expressed in

5 Bacillus subtilis (See e.g., WO 07/044993), and PMN, the purified neutral metalloprotease from Bacillus amyloliquefaciens.

Suitable mannanases include, but are not limited to those of bacterial or fungal origin. Chemically or genetically modified mutants are included in some embodiments. Various mannanases are known which

10 find use in the present disclosure (See e.g., U.S. Pat. No. 6,566,114, U.S. Pat. No. 6,602,842, and US Patent No. 6,440,991, all of which are incorporated herein by reference). Commercially available mannanases include, but are not limited to MANNASTAR®, PURABRITE™, and MANNAWAY®.

15 Suitable lipases include those of bacterial or fungal origin. Chemically modified, proteolytically modified, or protein engineered mutants are included. Examples of useful lipases include those from the genera *Humicola* (e.g., *H. lanuginosa*, EP258068 and EP305216; *H. insolens*, WO96/13580), *Pseudomonas* (e.g., *P. alcaligenes* or *P. pseudoalcaligenes*, EP218272; *P. cepacia*, EP331376; *P. stutzeri*, GB1372034; *P. fluorescens* and *Pseudomonas* sp. strain SD 705, WO95/06720 and WO96/27002; *P. wisconsinensis*, WO96/12012); and *Bacillus* (e.g., *B. subtilis*, Dartois et al., *Biochemica et Biophysica Acta* 1131:253-360; *B. stearothermophilus*, JP64/744992; *B. pumilus*,

20 *pseudoalcaligenes*, EP218272; *P. cepacia*, EP331376; *P. stutzeri*, GB1372034; *P. fluorescens* and *Pseudomonas* sp. strain SD 705, WO95/06720 and WO96/27002; *P. wisconsinensis*, WO96/12012); and *Bacillus* (e.g., *B. subtilis*, Dartois et al., *Biochemica et Biophysica Acta* 1131:253-360; *B. stearothermophilus*, JP64/744992; *B. pumilus*,

25 WO91/16422). Furthermore, a number of cloned lipases find use in some embodiments of the present disclosure, including but not limited to *Penicillium camembertii* lipase (See, Yamaguchi et al., *Gene* 103:61-67 [1991]), *Geotrichum candidum* lipase (See, Shimada et al., *J. Biochem.*, 106:383-388 [1989]), and various *Rhizopus* lipases such as *R. delemar*

30 lipase (See, Hass et al., *Gene* 109:117-113 [1991]), a *R. niveus* lipase (Kugimiya et al., *Biosci. Biotech. Biochem.* 56:716-719 [1992]) and *R. oryzae* lipase. Additional lipases useful herein include, for example, those disclosed in WO92/05249, WO94/01541, WO95/35381, WO96/00292, WO95/30744, WO94/25578, WO95/14783, WO95/22615, WO97/04079,

WO97/07202, EP407225 and EP260105. Other types of lipase polypeptide enzymes such as cutinases also find use in some embodiments, including but not limited to the cutinase derived from *Pseudomonas mendocina* (See, WO 88/09367), and the cutinase derived from *Fusarium solani pisi* (See, WO 90/09446). Examples of certain commercially available lipase enzymes useful herein include M1 LIPASE™, LUMA FAST™, and LIPOMAX™ (Genencor); LIPEX®, LIPOLASE® and LIPOLASE® ULTRA (Novozymes); and LIPASE P™ "Amano" (Amano Pharmaceutical Co. Ltd., Japan).

10 Suitable polyesterases include, for example, those disclosed in WO01/34899, WO01/14629 and U.S. Patent No. 6933140.

A detergent composition herein can also comprise 2,6-beta-D-fructan hydrolase, which is effective for removal/cleaning of certain biofilms present on household and/or industrial textiles/laundry.

15 Suitable amylases include, but are not limited to those of bacterial or fungal origin. Chemically or genetically modified mutants are included in some embodiments. Amylases that find use in the present disclosure, include, but are not limited to α -amylases obtained from *B. licheniformis* (See e.g., GB 1,296,839). Additional suitable amylases include those
20 found in W09510603, WO9526397, WO9623874, WO9623873, WO9741213, WO9919467, WO0060060, WO0029560, WO9923211, WO9946399, WO0060058, WO0060059, WO9942567, WO0114532, WO02092797, WO0166712, WO0188107, WO0196537, WO0210355, WO9402597, WO0231124, WO9943793, WO9943794, WO2004113551,
25 WO2005001064, WO2005003311, WO0164852, WO2006063594, WO2006066594, WO2006066596, WO2006012899, WO2008092919, WO2008000825, WO2005018336, WO2005066338, WO2009140504, WO2005019443, WO2010091221, WO2010088447, WO0134784, WO2006012902, WO2006031554, WO2006136161, WO2008101894,
30 WO2010059413, WO2011098531, WO2011080352, WO2011080353, WO2011080354, WO2011082425, WO2011082429, WO2011076123, WO2011087836, WO2011076897, WO94183314, WO9535382, WO9909183, WO9826078, WO9902702, WO9743424, WO9929876, WO9100353, WO9605295, WO9630481, WO9710342, WO2008088493,

WO2009149419, WO2009061381, WO2009100102, WO2010104675, WO2010117511, and WO2010115021.

Suitable amylases include, for example, commercially available amylases such as STAINZYME[®], STAINZYME PLUS[®], NATALASE[®],
5 DURAMYL[®], TERMAMYL[®], TERMAMYL ULTRA[®], FUNGAMYL[®] and BAN[™] (Novo Nordisk A/S and Novozymes A/S); RAPIDASE[®], POWERASE[®], PURASTAR[®] and PREFERENZ[™] (DuPont Industrial Biosciences).

Suitable peroxidases/oxidases contemplated for use in the
10 compositions include those of plant, bacterial or fungal origin. Chemically modified or protein engineered mutants are included. Examples of peroxidases useful herein include those from the genus *Coprinus* (e.g., *C. cinereus*, WO93/24618, WO95/10602, and WO98/15257), as well as those referenced in WO 2005056782, WO2007106293, WO2008063400,
15 WO2008106214, and WO2008106215. Commercially available peroxidases useful herein include, for example, GUARDZYME[™] (Novo Nordisk A/S and Novozymes A/S).

In some embodiments, peroxidases are used in combination with hydrogen peroxide or a source thereof (e.g., a percarbonate, perborate or
20 persulfate) in the compositions. In some alternative embodiments, oxidases are used in combination with oxygen. Both types of enzymes are used for "solution bleaching" (i.e., to prevent transfer of a textile dye from a dyed fabric to another fabric when the fabrics are washed together in a wash liquor), preferably together with an enhancing agent (See e.g., WO
25 94/12621 and WO 95/01426). Suitable peroxidases/oxidases include, but are not limited to those of plant, bacterial or fungal origin. Chemically or genetically modified mutants are included in some embodiments.

Enzymes that may be comprised in a detergent composition herein may be stabilized using conventional stabilizing agents, e.g., a polyol such
30 as propylene glycol or glycerol; a sugar or sugar alcohol; lactic acid; boric acid or a boric acid derivative (e.g., an aromatic borate ester).

A detergent composition herein may contain about 1 wt% to about 65 wt% of a detergent builder or complexing agent such as zeolite, diphosphate, triphosphate, phosphonate, citrate, nitrilotriacetic acid (NTA),

ethylenediaminetetraacetic acid (EDTA), diethylenetriaminepentaacetic acid (DTMPA), alkyl- or alkenylsuccinic acid, soluble silicates or layered silicates (e.g., SKS-6 from Hoechst). A detergent may also be unbuilt, i.e., essentially free of detergent builder.

5 A detergent composition in certain embodiments may comprise one or more other types of polymers in addition to the present α -glucan oligomers/polymers and/or the present α -glucan ether compounds. Examples of other types of polymers useful herein include carboxymethyl cellulose (CMC), poly(vinylpyrrolidone) (PVP), polyethylene glycol (PEG),
10 poly(vinyl alcohol) (PVA), polycarboxylates such as polyacrylates, maleic/acrylic acid copolymers and lauryl methacrylate/acrylic acid copolymers.

 A detergent composition herein may contain a bleaching system. For example, a bleaching system can comprise an H_2O_2 source such as
15 perborate or percarbonate, which may be combined with a peracid-forming bleach activator such as tetraacetythylenediamine (TAED) or nonanoyloxybenzenesulfonate (NOBS). Alternatively, a bleaching system may comprise peroxyacids (e.g., amide, imide, or sulfone type peroxyacids). Alternatively still, a bleaching system can be an enzymatic
20 bleaching system comprising perhydrolase, for example, such as the system described in WO2005/056783.

 A detergent composition herein may also contain conventional detergent ingredients such as fabric conditioners, clays, foam boosters, suds suppressors, anti-corrosion agents, soil-suspending agents, anti-soil
25 redeposition agents, dyes, bactericides, tarnish inhibitors, optical brighteners, or perfumes. The pH of a detergent composition herein (measured in aqueous solution at use concentration) is usually neutral or alkaline (e.g., pH of about 7.0 to about 11.0).

 Particular forms of detergent compositions that can be adapted for
30 purposes disclosed herein are disclosed in, for example, US20090209445A1, US20100081598A1, US7001878B2, EP1504994B1, WO2001085888A2, WO2003089562A1, WO2009098659A1, WO2009098660A1, WO2009112992A1, WO2009124160A1, WO2009152031A1, WO2010059483A1, WO2010088112A1,

- WO2010090915A1, WO2010135238A1, WO2011094687A1,
WO2011094690A1, WO2011127102A1, WO2011163428A1,
WO2008000567A1, WO2006045391A1, WO2006007911A1,
WO2012027404A1, EP1740690B1, WO2012059336A1, US6730646B1,
5 WO2008087426A1, WO2010116139A1, and WO2012104613A1, all of
which are incorporated herein by reference.

Laundry detergent compositions herein can optionally be heavy
duty (all purpose) laundry detergent compositions. Exemplary heavy duty
laundry detergent compositions comprise a deterative surfactant (10%-40%
10 wt/wt), including an anionic deterative surfactant (selected from a group of
linear or branched or random chain, substituted or unsubstituted alkyl
sulphates, alkyl sulphonates, alkyl alkoxyated sulphate, alkyl phosphates,
alkyl phosphonates, alkyl carboxylates, and/or mixtures thereof), and
optionally non-ionic surfactant (selected from a group of linear or branched
15 or random chain, substituted or unsubstituted alkyl alkoxyated alcohol,
e.g., C₈-C₁₈ alkyl ethoxyated alcohols and/or C₆-C₁₂ alkyl phenol
alkoxyates), where the weight ratio of anionic deterative surfactant (with a
hydrophilic index (Hlc) of from 6.0 to 9) to non-ionic deterative surfactant is
greater than 1:1. Suitable deterative surfactants also include cationic
20 deterative surfactants (selected from a group of alkyl pyridinium
compounds, alkyl quaternary ammonium compounds, alkyl quaternary
phosphonium compounds, alkyl ternary sulphonium compounds, and/or
mixtures thereof); zwitterionic and/or amphoteric deterative surfactants
(selected from a group of alkanolamine sulfo-betaines); ampholytic
25 surfactants; semi-polar non-ionic surfactants and mixtures thereof.

A detergent herein such as a heavy duty laundry detergent
composition may optionally include, a surfactancy boosting polymer
consisting of amphiphilic alkoxyated grease cleaning polymers (selected
from a group of alkoxyated polymers having branched hydrophilic and
30 hydrophobic properties, such as alkoxyated polyalkylenimines in the
range of 0.05 wt% - 10 wt%) and/or random graft polymers (typically
comprising of hydrophilic backbone comprising monomers selected from
the group consisting of: unsaturated C₁-C₆ carboxylic acids, ethers,
alcohols, aldehydes, ketones, esters, sugar units, alkoxy units, maleic

anhydride, saturated polyalcohols such as glycerol, and mixtures thereof;
and hydrophobic side chain(s) selected from the group consisting of: C₄-
C₂₅ alkyl group, polypropylene, polybutylene, vinyl ester of a saturated C₁-
C₆ mono-carboxylic acid, C₁-C₆ alkyl ester of acrylic or methacrylic acid,
5 and mixtures thereof.

A detergent herein such as a heavy duty laundry detergent
composition may optionally include additional polymers such as soil
release polymers (include anionically end-capped polyesters, for example
SRP1, polymers comprising at least one monomer unit selected from
10 saccharide, dicarboxylic acid, polyol and combinations thereof, in random
or block configuration, ethylene terephthalate-based polymers and co-
polymers thereof in random or block configuration, for example REPEL-O-
TEX SF, SF-2 AND SRP6, TEXCARE SRA100, SRA300, SRN100,
SRN170, SRN240, SRN300 AND SRN325, MARLOQUEST SL), anti-
15 redeposition polymers (0.1 wt% to 10 wt%), include carboxylate polymers,
such as polymers comprising at least one monomer selected from acrylic
acid, maleic acid (or maleic anhydride), fumaric acid, itaconic acid, aconitic
acid, mesaconic acid, citraconic acid, methylenemalonic acid, and any
mixture thereof, vinylpyrrolidone homopolymer, and/or polyethylene glycol,
20 molecular weight in the range of from 500 to 100,000 Da); and polymeric
carboxylate (such as maleate/acrylate random copolymer or polyacrylate
homopolymer).

A detergent herein such as a heavy duty laundry detergent
composition may optionally further include saturated or unsaturated fatty
25 acids, preferably saturated or unsaturated C₁₂-C₂₄ fatty acids (0 wt% to 10
wt%); deposition aids in addition to the α -glucan ether compound
disclosed herein (examples for which include polysaccharides, cellulosic
polymers, poly diallyl dimethyl ammonium halides (DADMAC), and co-
polymers of DAD MAC with vinyl pyrrolidone, acrylamides, imidazoles,
30 imidazolinium halides, and mixtures thereof, in random or block
configuration, cationic guar gum, cationic starch, cationic polyacrylamides,
and mixtures thereof.

A detergent herein such as a heavy duty laundry detergent
composition may optionally further include dye transfer inhibiting agents,

examples of which include manganese phthalocyanine, peroxidases, polyvinylpyrrolidone polymers, polyamine N-oxide polymers, copolymers of N-vinylpyrrolidone and N-vinylimidazole, polyvinylloxazolidones and polyvinylimidazoles and/or mixtures thereof; chelating agents, examples of which include ethylene-diamine-tetraacetic acid (EDTA), diethylene triamine penta methylene phosphonic acid (DTPMP), hydroxy-ethane diphosphonic acid (HEDP), ethylenediamine N,N'-disuccinic acid (EDDS), methyl glycine diacetic acid (MGDA), diethylene triamine penta acetic acid (DTPA), propylene diamine tetracetic acid (PDTA), 2-hydroxypyridine-N-oxide (HPNO), or methyl glycine diacetic acid (MGDA), glutamic acid N,N-diacetic acid (N,N-dicarboxymethyl glutamic acid tetrasodium salt (GLDA), nitrilotriacetic acid (NTA), 4,5-dihydroxy-m-benzenedisulfonic acid, citric acid and any salts thereof, N-hydroxyethylethylenediaminetriacetic acid (HEDTA), triethylenetetraaminehexaacetic acid (TTHA), N-hydroxyethyliminodiacetic acid (HEIDA), dihydroxyethylglycine (DHEG), ethylenediaminetetrapropionic acid (EDTP), and derivatives thereof.

A detergent herein such as a heavy duty laundry detergent composition may optionally include silicone or fatty-acid based suds suppressors; hueing dyes, calcium and magnesium cations, visual signaling ingredients, anti-foam (0.001 wt% to about 4.0 wt%), and/or a structurant/thickener (0.01 wt% to 5 wt%) selected from the group consisting of diglycerides and triglycerides, ethylene glycol distearate, microcrystalline cellulose, microfiber cellulose, biopolymers, xanthan gum, gellan gum, and mixtures thereof). Such structurant/thickener would be in addition to the one or more of the present α -glucan oligomers/polymers and/or α -glucan ether compounds comprised in the detergent.

A detergent herein can be in the form of a heavy duty dry/solid laundry detergent composition, for example. Such a detergent may include: (i) a deterative surfactant, such as any anionic deterative surfactant disclosed herein, any non-ionic deterative surfactant disclosed herein, any cationic deterative surfactant disclosed herein, any zwitterionic and/or amphoteric deterative surfactant disclosed herein, any ampholytic surfactant, any semi-polar non-ionic surfactant, and mixtures thereof; (ii) a builder, such as any phosphate-free builder (e.g., zeolite builders in the

range of 0 wt% to less than 10 wt%), any phosphate builder (e.g., sodium tri-polyphosphate in the range of 0 wt% to less than 10 wt%), citric acid, citrate salts and nitrilotriacetic acid, any silicate salt (e.g., sodium or potassium silicate or sodium meta-silicate in the range of 0 wt% to less than 10 wt%); any carbonate salt (e.g., sodium carbonate and/or sodium bicarbonate in the range of 0 wt% to less than 80 wt%), and mixtures thereof; (iii) a bleaching agent, such as any photobleach (e.g., sulfonated zinc phthalocyanines, sulfonated aluminum phthalocyanines, xanthenes dyes, and mixtures thereof), any hydrophobic or hydrophilic bleach activator (e.g., dodecanoyl oxybenzene sulfonate, decanoyl oxybenzene sulfonate, decanoyl oxybenzoic acid or salts thereof, 3,5,5-trimethylhexanoyl oxybenzene sulfonate, tetraacetyl ethylene diamine-TAED, nonanoyloxybenzene sulfonate-NOBS, nitrile quats, and mixtures thereof), any source of hydrogen peroxide (e.g., inorganic perhydrate salts, examples of which include mono or tetra hydrate sodium salt of perborate, percarbonate, persulfate, perphosphate, or persilicate), any preformed hydrophilic and/or hydrophobic peracids (e.g., percarboxylic acids and salts, percarbonic acids and salts, perimidic acids and salts, peroxymonosulfuric acids and salts, and mixtures thereof); and/or (iv) any other components such as a bleach catalyst (e.g., imine bleach boosters examples of which include iminium cations and polyions, iminium zwitterions, modified amines, modified amine oxides, N-sulphonyl imines, N-phosphonyl imines, N-acyl imines, thiadiazole dioxides, perfluoroimines, cyclic sugar ketones, and mixtures thereof), and a metal-containing bleach catalyst (e.g., copper, iron, titanium, ruthenium, tungsten, molybdenum, or manganese cations along with an auxiliary metal cations such as zinc or aluminum and a sequester such as EDTA, ethylenediaminetetra(methylenephosphonic acid)).

Compositions disclosed herein can be in the form of a dishwashing detergent composition. Examples of dishwashing detergents include automatic dishwashing detergents (typically used in dishwasher machines) and hand-washing dish detergents. A dishwashing detergent composition can be in any dry or liquid/aqueous form as disclosed herein, for example. Components that may be included in certain embodiments of a

dishwashing detergent composition include, for example, one or more of a phosphate; oxygen- or chlorine-based bleaching agent; non-ionic surfactant; alkaline salt (e.g., metasilicates, alkali metal hydroxides, sodium carbonate); any active enzyme disclosed herein; anti-corrosion agent (e.g., sodium silicate); anti-foaming agent; additives to slow down the removal of glaze and patterns from ceramics; perfume; anti-caking agent (in granular detergent); starch (in tablet-based detergents); gelling agent (in liquid/gel based detergents); and/or sand (powdered detergents).

Dishwashing detergents such as an automatic dishwasher detergent or liquid dishwashing detergent can comprise (i) a non-ionic surfactant, including any ethoxylated non-ionic surfactant, alcohol alkoxyated surfactant, epoxy-capped poly(oxyalkylated) alcohol, or amine oxide surfactant present in an amount from 0 to 10 wt%; (ii) a builder, in the range of about 5-60 wt%, including any phosphate builder (e.g., mono-phosphates, di-phosphates, tri-polyphosphates, other oligomeric-polyphosphates, sodium tripolyphosphate-STPP), any phosphate-free builder (e.g., amino acid-based compounds including methyl-glycine-diacetic acid [MGDA] and salts or derivatives thereof, glutamic-N,N-diacetic acid [GLDA] and salts or derivatives thereof, iminodisuccinic acid (IDS) and salts or derivatives thereof, carboxy methyl inulin and salts or derivatives thereof, nitrilotriacetic acid [NTA], diethylene triamine penta acetic acid [DTPA], B-alaninediacetic acid [B-ADA] and salts thereof), homopolymers and copolymers of poly-carboxylic acids and partially or completely neutralized salts thereof, monomeric polycarboxylic acids and hydroxycarboxylic acids and salts thereof in the range of 0.5 wt% to 50 wt%, or sulfonated/carboxylated polymers in the range of about 0.1 wt% to about 50 wt%; (iii) a drying aid in the range of about 0.1 wt% to about 10 wt% (e.g., polyesters, especially anionic polyesters, optionally together with further monomers with 3 to 6 functionalities – typically acid, alcohol or ester functionalities which are conducive to polycondensation, polycarbonate-, polyurethane- and/or polyurea-polyorganosiloxane compounds or precursor compounds thereof, particularly of the reactive cyclic carbonate and urea type); (iv) a silicate in the range from about 1 wt% to about 20 wt% (e.g., sodium or potassium silicates such as sodium

- disilicate, sodium meta-silicate and crystalline phyllosilicates); (v) an inorganic bleach (e.g., perhydrate salts such as perborate, percarbonate, perphosphate, persulfate and persilicate salts) and/or an organic bleach (e.g., organic peroxyacids such as diacyl- and tetraacylperoxides,
- 5 especially diperoxydodecanedioic acid, diperoxytetradecanedioic acid, and diperoxyhexadecanedioic acid); (vi) a bleach activator (e.g., organic peracid precursors in the range from about 0.1 wt% to about 10 wt%) and/or bleach catalyst (e.g., manganese triazacyclononane and related complexes; Co, Cu, Mn, and Fe bispyridylamine and related complexes;
- 10 and pentamine acetate cobalt(III) and related complexes); (vii) a metal care agent in the range from about 0.1 wt% to 5 wt% (e.g., benzotriazoles, metal salts and complexes, and/or silicates); and/or (viii) any active enzyme disclosed herein in the range from about 0.01 to 5.0 mg of active enzyme per gram of automatic dishwashing detergent composition, and an
- 15 enzyme stabilizer component (e.g., oligosaccharides, polysaccharides, and inorganic divalent metal salts).

Various examples of detergent formulations comprising at least one α -glucan ether compound (e.g., a carboxyalkyl α -glucan ether such as carboxymethyl α -glucan) are disclosed below (1-19):

- 20 1) A detergent composition formulated as a granulate having a bulk density of at least 600 g/L comprising: linear alkylbenzenesulfonate (calculated as acid) at about 7-12 wt%; alcohol ethoxysulfate (e.g., C₁₂-C₁₈ alcohol, 1-2 ethylene oxide [EO]) or alkyl sulfate (e.g., C₁₆-C₁₈) at about 1-4 wt%; alcohol ethoxylate (e.g., C₁₄-C₁₅ alcohol) at about 5-9 wt%; sodium
- 25 carbonate at about 14-20 wt%; soluble silicate (e.g., Na₂O₂SiO₂) at about 2-6 wt%; zeolite (e.g., NaAlSiO₄) at about 15-22 wt%; sodium sulfate at about 0-6 wt%; sodium citrate/citric acid at about 0-15 wt%; sodium perborate at about 11-18 wt%; TAED at about 2-6 wt%; α -glucan ether up to about 2 wt%; other polymers (e.g., maleic/acrylic acid copolymer, PVP,
- 30 PEG) at about 0-3 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., suds suppressors, perfumes, optical brightener, photobleach) at about 0-5 wt%.

2) A detergent composition formulated as a granulate having a bulk density of at least 600 g/L comprising: linear alkylbenzenesulfonate (calculated as acid) at about 6-11 wt%; alcohol ethoxysulfate (e.g., C12-18 alcohol, 1-2 EO) or alkyl sulfate (e.g., C16-18) at about 1-3 wt%; alcohol ethoxylate (e.g., C14-15 alcohol) at about 5-9 wt%; sodium carbonate at about 15-21 wt%; soluble silicate (e.g., $\text{Na}_2\text{O}_2\text{SiO}_2$) at about 1-4 wt%; zeolite (e.g., NaAlSiO_4) at about 24-34 wt%; sodium sulfate at about 4-10 wt%; sodium citrate/citric acid at about 0-15 wt%; sodium perborate at about 11-18 wt%; TAED at about 2-6 wt%; α -glucan ether up to about 2 wt%; other polymers (e.g., maleic/acrylic acid copolymer, PVP, PEG) at about 1-6 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., suds suppressors, perfumes, optical brightener, photobleach) at about 0-5 wt%.

3) A detergent composition formulated as a granulate having a bulk density of at least 600 g/L comprising: linear alkylbenzenesulfonate (calculated as acid) at about 5-9 wt%; alcohol ethoxysulfate (e.g., C12-18 alcohol, 7 EO) at about 7-14 wt%; soap as fatty acid (e.g., C16-22 fatty acid) at about 1-3 wt%; sodium carbonate at about 10-17 wt%; soluble silicate (e.g., $\text{Na}_2\text{O } 2\text{SiO}_2$) at about 3-9 wt%; zeolite (e.g., NaAlSiO_4) at about 23-33 wt%; sodium sulfate at about 0-4 wt%; sodium perborate at about 8-16 wt%; TAED at about 2-8 wt%; phosphonate (e.g., EDTMPA) at about 0-1 wt%; α -glucan ether up to about 2 wt%; other polymers (e.g., maleic/acrylic acid copolymer, PVP, PEG) at about 0-3 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., suds suppressors, perfumes, optical brightener) at about 0-5 wt%.

4) A detergent composition formulated as a granulate having a bulk density of at least 600 g/L comprising: linear alkylbenzenesulfonate (calculated as acid) at about 8-12 wt%; alcohol ethoxylate (e.g., C12-18 alcohol, 7 EO) at about 10-25 wt%; sodium carbonate at about 14-22 wt%; soluble silicate (e.g., $\text{Na}_2\text{O } 2\text{SiO}_2$) at about 1-5 wt%; zeolite (e.g., NaAlSiO_4) at about 25-35 wt%; sodium sulfate at about 0-10 wt%; sodium perborate at about 8-16 wt%; TAED at about 2-8 wt%; phosphonate (e.g., EDTMPA) at about 0-1 wt%; α -glucan ether up to about 2 wt%; other

polymers (e.g., maleic/acrylic acid copolymer, PVP, PEG) at about 1-3 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., suds suppressors, perfumes) at about 0-5 wt%.

- 5 5) An aqueous liquid detergent composition comprising: linear alkylbenzenesulfonate (calculated as acid) at about 15-21 wt%; alcohol ethoxylate (e.g., C12-18 alcohol, 7 EO; or C12-15 alcohol, 5 EO) at about 12-18 wt%; soap as fatty acid (e.g., oleic acid) at about 3-13 wt%; alkenylsuccinic acid (C12-14) at about 0-13 wt%; aminoethanol at about 8-
10 18 wt%; citric acid at about 2-8 wt%; phosphonate at about 0-3 wt%; α -glucan ether up to about 2 wt%; other polymers (e.g., PVP, PEG) at about 0-3 wt%; borate at about 0-2 wt%; ethanol at about 0-3 wt%; propylene glycol at about 8-14 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g.,
15 dispersants, suds suppressors, perfume, optical brightener) at about 0-5 wt%.

- 6) An aqueous structured liquid detergent composition comprising: linear alkylbenzenesulfonate (calculated as acid) at about 15-21 wt%; alcohol ethoxylate (e.g., C12-18 alcohol, 7 EO; or C12-15 alcohol, 5 EO)
20 at about 3-9 wt%; soap as fatty acid (e.g., oleic acid) at about 3-10 wt%; zeolite (e.g., NaAlSiO₄) at about 14-22 wt%; potassium citrate about 9-18 wt%; borate at about 0-2 wt%; α -glucan ether up to about 2 wt%; other polymers (e.g., PVP, PEG) at about 0-3 wt%; ethanol at about 0-3 wt%; anchoring polymers (e.g., lauryl methacrylate/acrylic acid copolymer,
25 molar ratio 25:1, MW 3800) at about 0-3 wt%; glycerol at about 0-5 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., dispersants, suds suppressors, perfume, optical brightener) at about 0-5 wt%.

- 7) A detergent composition formulated as a granulate having a bulk
30 density of at least 600 g/L comprising: fatty alcohol sulfate at about 5-10 wt%, ethoxylated fatty acid monoethanolamide at about 3-9 wt%; soap as fatty acid at about 0-3 wt%; sodium carbonate at about 5-10 wt%; soluble silicate (e.g., Na₂O 2SiO₂) at about 1-4 wt%; zeolite (e.g., NaAlSiO₄) at about 20-40 wt%; sodium sulfate at about 2-8 wt%; sodium perborate at

about 12-18 wt%; TAED at about 2-7 wt%; α -glucan ether up to about 2 wt%; other polymers (e.g., maleic/acrylic acid copolymer, PEG) at about 1-5 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., optical brightener, suds suppressors, perfumes) at about 0-5 wt%.

8) A detergent composition formulated as a granulate comprising: linear alkylbenzenesulfonate (calculated as acid) at about 8-14 wt%; ethoxylated fatty acid monoethanolamide at about 5-11 wt%; soap as fatty acid at about 0-3 wt%; sodium carbonate at about 4-10 wt%; soluble silicate (e.g., $\text{Na}_2\text{O} \cdot 2\text{SiO}_2$) at about 1-4 wt%; zeolite (e.g., NaAlSiO_4) at about 30-50 wt%; sodium sulfate at about 3-11 wt%; sodium citrate at about 5-12 wt%; α -glucan ether up to about 2 wt%; other polymers (e.g., PVP, maleic/acrylic acid copolymer, PEG) at about 1-5 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., suds suppressors, perfumes) at about 0-5 wt%.

9) A detergent composition formulated as a granulate comprising: linear alkylbenzenesulfonate (calculated as acid) at about 6-12 wt%; nonionic surfactant at about 1-4 wt%; soap as fatty acid at about 2-6 wt%; sodium carbonate at about 14-22 wt%; zeolite (e.g., NaAlSiO_4) at about 18-32 wt%; sodium sulfate at about 5-20 wt%; sodium citrate at about 3-8 wt%; sodium perborate at about 4-9 wt%; bleach activator (e.g., NOBS or TAED) at about 1-5 wt%; α -glucan ether up to about 2 wt%; other polymers (e.g., polycarboxylate or PEG) at about 1-5 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., optical brightener, perfume) at about 0-5 wt%.

10) An aqueous liquid detergent composition comprising: linear alkylbenzenesulfonate (calculated as acid) at about 15-23 wt%; alcohol ethoxysulfate (e.g., C12-15 alcohol, 2-3 EO) at about 8-15 wt%; alcohol ethoxylate (e.g., C12-15 alcohol, 7 EO; or C12-15 alcohol, 5 EO) at about 3-9 wt%; soap as fatty acid (e.g., lauric acid) at about 0-3 wt%; aminoethanol at about 1-5 wt%; sodium citrate at about 5-10 wt%; hydrotrope (e.g., sodium toluenesulfonate) at about 2-6 wt%; borate at about 0-2 wt%; α -glucan ether up to about 1 wt%; ethanol at about 1-3

wt%; propylene glycol at about 2-5 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., dispersants, perfume, optical brighteners) at about 0-5 wt%.

- 5 11) An aqueous liquid detergent composition comprising: linear alkylbenzenesulfonate (calculated as acid) at about 20-32 wt%; alcohol ethoxylate (e.g., C12-15 alcohol, 7 EO; or C12-15 alcohol, 5 EO) at about 6-12 wt%; aminoethanol at about 2-6 wt%; citric acid at about 8-14 wt%; borate at about 1-3 wt%; α -glucan ether up to about 2 wt%; ethanol at
10 about 1-3 wt%; propylene glycol at about 2-5 wt%; other polymers (e.g., maleic/acrylic acid copolymer, anchoring polymer such as lauryl methacrylate/acrylic acid copolymer) at about 0-3 wt%; glycerol at about 3-8 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., hydrotropes,
15 dispersants, perfume, optical brighteners) at about 0-5 wt%.

- 12) A detergent composition formulated as a granulate having a bulk density of at least 600 g/L comprising: anionic surfactant (e.g., linear alkylbenzenesulfonate, alkyl sulfate, alpha-olefinsulfonate, alpha-sulfo fatty acid methyl esters, alkanesulfonates, soap) at about 25-40 wt%;
20 nonionic surfactant (e.g., alcohol ethoxylate) at about 1-10 wt%; sodium carbonate at about 8-25 wt%; soluble silicate (e.g., $\text{Na}_2\text{O} \cdot 2\text{SiO}_2$) at about 5-15 wt%; sodium sulfate at about 0-5 wt%; zeolite (NaAlSiO_4) at about 15-28 wt%; sodium perborate at about 0-20 wt%; bleach activator (e.g., TAED or NOBS) at about 0-5 wt%; α -glucan ether up to about 2 wt%;
25 optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., perfume, optical brighteners) at about 0-3 wt%.

- 13) Detergent compositions as described in (1)-(12) above, but in which all or part of the linear alkylbenzenesulfonate is replaced by C12-
30 C18 alkyl sulfate.

- 14) A detergent composition formulated as a granulate having a bulk density of at least 600 g/L comprising: C12-C18 alkyl sulfate at about 9-15 wt%; alcohol ethoxylate at about 3-6 wt%; polyhydroxy alkyl fatty acid amide at about 1-5 wt%; zeolite (e.g., NaAlSiO_4) at about 10-20 wt%;

layered disilicate (e.g., SK56 from Hoechst) at about 10-20 wt%; sodium carbonate at about 3-12 wt%; soluble silicate (e.g., $\text{Na}_2\text{O} \cdot 2\text{SiO}_2$) at 0-6 wt%; sodium citrate at about 4-8 wt%; sodium percarbonate at about 13-22 wt%; TAED at about 3-8 wt%; α -glucan ether up to about 2 wt%; other
5 polymers (e.g., polycarboxylates and PVP) at about 0-5 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., optical brightener, photobleach, perfume, suds suppressors) at about 0-5 wt%.

15) A detergent composition formulated as a granulate having a
10 bulk density of at least 600 g/L comprising: C12-C18 alkyl sulfate at about 4-8 wt%; alcohol ethoxylate at about 11-15 wt%; soap at about 1-4 wt%; zeolite MAP or zeolite A at about 35-45 wt%; sodium carbonate at about 2-8 wt%; soluble silicate (e.g., $\text{Na}_2\text{O} \cdot 2\text{SiO}_2$) at 0-4 wt%; sodium percarbonate at about 13-22 wt%; TAED at about 1-8 wt%; α -glucan ether
15 up to about 3 wt%; other polymers (e.g., polycarboxylates and PVP) at about 0-3 wt%; optionally an enzyme(s) (calculated as pure enzyme protein) at about 0.0001-0.1 wt%; and minor ingredients (e.g., optical brightener, phosphonate, perfume) at about 0-3 wt%.

16) Detergent formulations as described in (1)-(15) above, but that
20 contain a stabilized or encapsulated peracid, either as an additional component or as a substitute for an already specified bleach system(s).

17) Detergent compositions as described in (1), (3), (7), (9) and (12) above, but in which perborate is replaced by percarbonate.

18) Detergent compositions as described in (1), (3), (7), (9), (12),
25 (14) and (15) above, but that additionally contain a manganese catalyst. A manganese catalyst, for example, is one of the compounds described by Hage et al. (1994, *Nature* 369:637-639), which is incorporated herein by reference.

19) Detergent compositions formulated as a non-aqueous
30 detergent liquid comprising a liquid non-ionic surfactant (e.g., a linear alkoxyated primary alcohol), a builder system (e.g., phosphate), α -glucan ether, optionally an enzyme(s), and alkali. The detergent may also comprise an anionic surfactant and/or bleach system.

In another embodiment, the present α -glucan oligomers/polymers (non-derivatized) may be partially or completely substituted for the α -glucan ether component in any of the above exemplary formulations.

It is believed that numerous commercially available detergent formulations can be adapted to include a poly α -1,3-1,6-glucan ether compound. Examples include PUREX® ULTRAPACKS (Henkel), FINISH® QUANTUM (Reckitt Benckiser), CLOROX™ 2 PACKS (Clorox), OXICLEAN MAX FORCE POWER PAKS (Church & Dwight), TIDE® STAIN RELEASE, CASCADE® ACTIONPACS, and TIDE® PODS™ (Procter & Gamble).

In a further embodiment to any of the above embodiments, a personal care composition, a fabric care composition or a laundry care composition is provided comprising the glucan ether composition described in any of the preceding embodiments.

The present α -glucan oligomer/polymer composition and/or the present α -glucan ether composition may be applied as a surface substantive treatment to a fabric, yarn or fiber. In yet a further embodiment, a fabric, yarn or fiber is provided comprising the present α -glucan oligomer/polymer composition, the present α -glucan ether composition, or a combination thereof.

The α -glucan ether compound disclosed herein may be used to alter viscosity of an aqueous composition. The α -glucan ether compound herein can have a relatively low DoS and still be an effective viscosity modifier. It is believed that the viscosity modification effect of the disclosed α -glucan ether compounds may be coupled with a rheology modification effect. It is further believed that, by contacting a hydrocolloid or aqueous solution herein with a surface (e.g., fabric surface), one or more α -glucan ether compounds and/or the present α -glucan oligomer/polymer composition, the compounds will adsorb to the surface.

In another embodiment, a method for preparing an aqueous composition, the method is provided comprising: contacting an aqueous composition with the present α -glucan ether compound wherein the aqueous composition comprises a cellulase, a protease or a combination thereof.

In another embodiment, a method to produce a glucan ether composition is provided comprising:

- a. Providing an α -glucan oligomer/polymer composition comprising:
 - i. 25-35 α -(1,3) glycosidic linkages;
 - 5 ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons;
 - v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - 10 vi. a solubility of at least 20% (w/w) in water at 25 °C; and
 - vii. a polydispersity index of less than 5;
- b. contacting the α -glucan oligomer/polymer composition of (a) in a reaction under alkaline conditions with at least one etherification agent comprising an organic group; whereby an α -glucan ether is produced has a degree of substitution (DoS) with at least one organic group of about 0.05 to about 3.0; and
- 15 c. optionally isolating the α -glucan ether produced in step (b).

In another embodiment, a method of treating an article of clothing, textile or fabric is provided comprising:

- a. providing a composition selected from
 - i. a fabric care composition as described above;
 - ii. a laundry care composition as described above;
 - iii. an α -glucan ether composition as described above;
 - 25 iv. an α -glucan oligomer/polymer composition comprising:
 - i. 25-35 α -(1,3) glycosidic linkages;
 - ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons;
 - 30 v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - vi. a solubility of at least 20% (w/w) in water at 25 °C; and

- vii. a polydispersity index of less than 5;
- v. any combination of (i) through (iv).
- b. contacting under suitable conditions the composition of (a) with a fabric, textile or article of clothing whereby the fabric, textile or article of clothing is treated and receives a benefit;
- c. optionally rinsing the treated fabric or article of clothing of (b).

In a preferred embodiment of the above method, the composition of (a) is cellulase resistant, protease resistant or a combination thereof.

In another embodiment to the above method, the α -glucan oligomer/polymer composition and/or the α -glucan ether composition is a surface substantive.

In another embodiment to any of the above methods, the benefit is selected from the group consisting of improved fabric hand, improved resistance to soil deposition, improved colorfastness, improved wear resistance, improved wrinkle resistance, improved antifungal activity, improved stain resistance, improved cleaning performance when laundered, improved drying rates, improved dye, pigment or lake uptake, and any combination thereof.

A fabric herein can comprise natural fibers, synthetic fibers, semi-synthetic fibers, or any combination thereof. A semi-synthetic fiber herein is produced using naturally occurring material that has been chemically derivatized, an example of which is rayon. Non-limiting examples of fabric types herein include fabrics made of (i) cellulosic fibers such as cotton (e.g., broadcloth, canvas, chambray, chenille, chintz, corduroy, cretonne, damask, denim, flannel, gingham, jacquard, knit, matelassé, oxford, percale, poplin, plissé, sateen, seersucker, sheers, terry cloth, twill, velvet), rayon (e.g., viscose, modal, lyocell), linen, and Tencel®; (ii) proteinaceous fibers such as silk, wool and related mammalian fibers; (iii) synthetic fibers such as polyester, acrylic, nylon, and the like; (iv) long vegetable fibers from jute, flax, ramie, coir, kapok, sisal, henequen, abaca, hemp and sunn; and (v) any combination of a fabric of (i)-(iv). Fabric comprising a combination of fiber types (e.g., natural and synthetic) include those with both a cotton fiber and polyester, for example. Materials/articles containing one or more fabrics herein include, for

example, clothing, curtains, drapes, upholstery, carpeting, bed linens, bath linens, tablecloths, sleeping bags, tents, car interiors, etc. Other materials comprising natural and/or synthetic fibers include, for example, non-woven fabrics, paddings, paper, and foams.

5 An aqueous composition that is contacted with a fabric can be, for example, a fabric care composition (e.g., laundry detergent, fabric softener or other fabric treatment composition). Thus, a treatment method in certain embodiments can be considered a fabric care method or laundry method if employing a fabric care composition therein. A fabric care
10 composition herein can effect one or more of the following fabric care benefits: improved fabric hand, improved resistance to soil deposition, improved soil release, improved colorfastness, improved fabric wear resistance, improved wrinkle resistance, improved wrinkle removal, improved shape retention, reduction in fabric shrinkage, pilling reduction,
15 improved antifungal activity, improved stain resistance, improved cleaning performance when laundered, improved drying rates, improved dye, pigment or lake update, and any combination thereof.

 Examples of conditions (e.g., time, temperature, wash/rinse volumes) for conducting a fabric care method or laundry method herein
20 are disclosed in WO1997/003161 and U.S. Patent Nos. 4794661, 4580421 and 5945394, which are incorporated herein by reference. In other examples, a material comprising fabric can be contacted with an aqueous composition herein: (i) for at least about 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, or 120 minutes; (ii) at a temperature of at least
25 about 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, or 95 °C (e.g., for laundry wash or rinse: a “cold” temperature of about 15-30 °C, a “warm” temperature of about 30-50 °C, a “hot” temperature of about 50-95 °C); (iii) at a pH of about 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 (e.g., pH range of about 2-12, or about 3-11); (iv) at a salt (e.g., NaCl) concentration
30 of at least about 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, or 4.0 wt%; or any combination of (i)-(iv). The contacting step in a fabric care method or laundry method can comprise any of washing, soaking, and/or rinsing steps, for example.

In certain embodiments of treating a material comprising fabric, the present α -glucan oligomers/polymers and/or the present α -glucan ether compound component(s) of the aqueous composition adsorbs to the fabric. This feature is believed to render the compounds useful as anti-redeposition agents and/or anti-greying agents in fabric care compositions disclosed herein (in addition to their viscosity-modifying effect). An anti-redeposition agent or anti-greying agent herein helps keep soil from redepositing onto clothing in wash water after the soil has been removed. It is further contemplated that adsorption of one or more of the present compounds herein to a fabric enhances mechanical properties of the fabric.

Adsorption of the present α -glucan oligomers/polymer and/or the present α -glucan ethers to a fabric herein can be measured following the methodology disclosed in the below Examples, for example. Alternatively, adsorption can be measured using a colorimetric technique (e.g., Dubois et al., 1956, *Anal. Chem.* 28:350-356; Zemljič et al., 2006, *Lenzinger Berichte* 85:68-76; both incorporated herein by reference) or any other method known in the art.

Other materials that can be contacted in the above treatment method include surfaces that can be treated with a dish detergent (e.g., automatic dishwashing detergent or hand dish detergent). Examples of such materials include surfaces of dishes, glasses, pots, pans, baking dishes, utensils and flatware made from ceramic material, china, metal, glass, plastic (e.g., polyethylene, polypropylene, polystyrene, etc.) and wood (collectively referred to herein as "tableware"). Thus, the treatment method in certain embodiments can be considered a dishwashing method or tableware washing method, for example. Examples of conditions (e.g., time, temperature, wash volume) for conducting a dishwashing or tableware washing method herein are disclosed in U.S. Patent No. 8575083, which is incorporated herein by reference. In other examples, a tableware article can be contacted with an aqueous composition herein under a suitable set of conditions such as any of those disclosed above with regard to contacting a fabric-comprising material.

Certain embodiments of a method of treating a material herein further comprise a drying step, in which a material is dried after being contacted with the aqueous composition. A drying step can be performed directly after the contacting step, or following one or more additional steps that might follow the contacting step (e.g., drying of a fabric after being rinsed, in water for example, following a wash in an aqueous composition herein). Drying can be performed by any of several means known in the art, such as air drying (e.g., ~20-25 °C), or at a temperature of at least about 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 170, 175, 180, or 200 °C, for example. A material that has been dried herein typically has less than 3, 2, 1, 0.5, or 0.1 wt% water comprised therein. Fabric is a preferred material for conducting an optional drying step.

An aqueous composition used in a treatment method herein can be any aqueous composition disclosed herein, such as in the above embodiments or in the below Examples. Examples of aqueous compositions include detergents (e.g., laundry detergent or dish detergent) and water-containing dentifrices such as toothpaste.

In another embodiment, a method to alter the viscosity of an aqueous composition is provided comprising contacting one or more of the present α -glucan ether compounds with the aqueous composition, wherein the presence of the one or more α -glucan ether compounds alters (increases or decreases) the viscosity of the aqueous composition.

In a preferred aspect, the alteration in viscosity can be an increase and/or decrease of at least about 1%, 10%, 100%, 1000%, 100000%, or 1000000% (or any integer between 1% and 1000000%), for example, compared to the viscosity of the aqueous composition before the contacting step.

Etherification of the Present α -Glucan Oligomers/Polymers

The following steps can be taken to prepare the above etherification reaction.

The present α -glucan oligomers/polymers are contacted in a reaction under alkaline conditions with at least one etherification agent comprising an organic group. This step can be performed, for example, by first

preparing alkaline conditions by contacting the present α -glucan oligomers/polymers with a solvent and one or more alkali hydroxides to provide a mixture (e.g., slurry) or solution. The alkaline conditions of the etherification reaction can thus comprise an alkali hydroxide solution. The pH of the alkaline conditions can be at least about 11.0, 11.2, 11.4, 11.6, 11.8, 12.0, 12.2, 12.4, 12.6, 12.8, or 13.0.

Various alkali hydroxides can be used, such as sodium hydroxide, potassium hydroxide, calcium hydroxide, lithium hydroxide, and/or tetraethylammonium hydroxide. The concentration of alkali hydroxide in a preparation with the present α -glucan oligomers/polymers and a solvent can be from about 1-70 wt%, 5-50 wt%, 5-10 wt%, 10-50 wt%, 10-40 wt%, or 10-30 wt% (or any integer between 1 and 70 wt%). Alternatively, the concentration of alkali hydroxide such as sodium hydroxide can be at least about 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, or 30 wt%. An alkali hydroxide used to prepare alkaline conditions may be in a completely aqueous solution or an aqueous solution comprising one or more water-soluble organic solvents such as ethanol or isopropanol. Alternatively, an alkali hydroxide can be added as a solid to provide alkaline conditions.

Various organic solvents that can optionally be included or used as the main solvent when preparing the etherification reaction include alcohols, acetone, dioxane, isopropanol and toluene, for example. Toluene or isopropanol can be used in certain embodiments. An organic solvent can be added before or after addition of alkali hydroxide. The concentration of an organic solvent (e.g., isopropanol or toluene) in a preparation comprising the present α -glucan oligomers/polymers and an alkali hydroxide can be at least about 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, or 90 wt% (or any integer between 10 and 90 wt%).

Alternatively, solvents that can dissolve the present α -glucan oligomers/polymers can be used when preparing the etherification reaction. These solvents include, but are not limited to, lithium chloride(LiCl)/N,N-dimethyl-acetamide (DMAc), SO₂/diethylamine (DEA)/dimethyl sulfoxide (DMSO), LiCl/1,3-dimethyl-2-imidazolidinone

(DMI), N,N-dimethylformamide (DMF)/N₂O₄, DMSO/tetrabutyl-ammonium fluoride trihydrate (TBAF), N-methylmorpholine-N-oxide (NMMO), Ni(tren)(OH)₂ [tren¹/₄tris(2-aminoethyl)amine] aqueous solutions and melts of LiClO₄·3H₂O, NaOH/urea aqueous solutions, aqueous sodium

5 hydroxide, aqueous potassium hydroxide, formic acid, and ionic liquids.

The present α-glucan oligomers/polymers can be contacted with a solvent and one or more alkali hydroxides by mixing. Such mixing can be performed during or after adding these components with each other.

Mixing can be performed by manual mixing, mixing using an overhead
10 mixer, using a magnetic stir bar, or shaking, for example. In certain embodiments, the present α-glucan oligomers/polymers can first be mixed in water or an aqueous solution before it is mixed with a solvent and/or alkali hydroxide.

After contacting the present α-glucan oligomers/polymers, solvent,
15 and one or more alkali hydroxides with each other, the resulting composition can optionally be maintained at ambient temperature for up to 14 days. The term “ambient temperature” as used herein refers to a temperature between about 15-30 °C or 20-25 °C (or any integer between 15 and 30 °C). Alternatively, the composition can be heated with or
20 without reflux at a temperature from about 30 °C to about 150 °C (or any integer between 30 and 150 °C) for up to about 48 hours. The composition in certain embodiments can be heated at about 55 °C for about 30 minutes or about 60 minutes. Thus, a composition obtained from mixing the present α-glucan oligomers/polymers, solvent, and one or more
25 alkali hydroxides with each other can be heated at about 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, or 60 °C for about 30-90 minutes.

After contacting the present α-glucan oligomers/polymers, solvent, and one or more alkali hydroxides with each other, the resulting composition can optionally be filtered (with or without applying a
30 temperature treatment step). Such filtration can be performed using a funnel, centrifuge, press filter, or any other method and/or equipment known in the art that allows removal of liquids from solids. Though filtration would remove much of the alkali hydroxide, the filtered α-glucan

oligomers/polymers would remain alkaline (i.e., mercerized α -glucan), thereby providing alkaline conditions.

An etherification agent comprising an organic group can be contacted with the present α -glucan oligomers/polymers in a reaction under alkaline conditions in a method herein of producing the respective α -glucan ether compounds. For example, an etherification agent can be added to a composition prepared by contacting the present α -glucan oligomers/polymers composition, solvent, and one or more alkali hydroxides with each other as described above. Alternatively, an etherification agent can be included when preparing the alkaline conditions (e.g., an etherification agent can be mixed with the present α -glucan oligomers/polymers and solvent before mixing with alkali hydroxide).

An etherification agent herein can refer to an agent that can be used to etherify one or more hydroxyl groups of glucose monomeric units of the present α -glucan oligomers/polymers with an organic group as disclosed herein. Examples of organic groups include alkyl groups, hydroxy alkyl groups, and carboxy alkyl groups. One or more etherification agents may be used in the reaction.

Etherification agents suitable for preparing an alkyl α -glucan ether compound include, for example, dialkyl sulfates, dialkyl carbonates, alkyl halides (e.g., alkyl chloride), iodoalkanes, alkyl triflates (alkyl trifluoromethanesulfonates) and alkyl fluorosulfonates. Thus, examples of etherification agents for producing methyl α -glucan ethers include dimethyl sulfate, dimethyl carbonate, methyl chloride, iodomethane, methyl triflate and methyl fluorosulfonate. Examples of etherification agents for producing ethyl α -glucan ethers include diethyl sulfate, diethyl carbonate, ethyl chloride, iodoethane, ethyl triflate and ethyl fluorosulfonate. Examples of etherification agents for producing propyl α -glucan ethers include dipropyl sulfate, dipropyl carbonate, propyl chloride, iodopropane, propyl triflate and propyl fluorosulfonate. Examples of etherification agents for producing butyl α -glucan ethers include dibutyl sulfate, dibutyl carbonate, butyl chloride, iodobutane and butyl triflate.

Etherification agents suitable for preparing a hydroxyalkyl α -glucan ether compound include, for example, alkylene oxides such as ethylene

oxide, propylene oxide (e.g., 1,2-propylene oxide), butylene oxide (e.g., 1,2-butylene oxide; 2,3-butylene oxide; 1,4-butylene oxide), or combinations thereof. As examples, propylene oxide can be used as an etherification agent for preparing hydroxypropyl α -glucan, and ethylene oxide can be used as an etherification agent for preparing hydroxyethyl α -glucan. Alternatively, hydroxyalkyl halides (e.g., hydroxyalkyl chloride) can be used as etherification agents for preparing hydroxyalkyl α -glucan. Examples of hydroxyalkyl halides include hydroxyethyl halide, hydroxypropyl halide (e.g., 2-hydroxypropyl chloride, 3-hydroxypropyl chloride) and hydroxybutyl halide. Alternatively, alkylene chlorohydrins can be used as etherification agents for preparing hydroxyalkyl α -glucan ethers. Alkylene chlorohydrins that can be used include, but are not limited to, ethylene chlorohydrin, propylene chlorohydrin, butylene chlorohydrin, or combinations of these.

Etherification agents suitable for preparing a dihydroxyalkyl α -glucan ether compound include dihydroxyalkyl halides (e.g., dihydroxyalkyl chloride) such as dihydroxyethyl halide, dihydroxypropyl halide (e.g., 2,3-dihydroxypropyl chloride [i.e., 3-chloro-1,2-propanediol]), or dihydroxybutyl halide, for example. 2,3-dihydroxypropyl chloride can be used to prepare dihydroxypropyl α -glucan ethers, for example.

Etherification agents suitable for preparing a carboxyalkyl α -glucan ether compounds may include haloalkylates (e.g., chloroalkylate). Examples of haloalkylates include haloacetate (e.g., chloroacetate), 3-halopropionate (e.g., 3-chloropropionate) and 4-halobutyrate (e.g., 4-chlorobutyrate). For example, chloroacetate (monochloroacetate) (e.g., sodium chloroacetate) can be used as an etherification agent to prepare carboxymethyl α -glucan. An etherification agent herein can alternatively comprise a positively charged organic group.

An etherification agent in certain embodiments can etherify α -glucan oligomers/polymers with a positively charged organic group, where the carbon chain of the positively charged organic group only has a substitution with a positively charged group (e.g., substituted ammonium group such as trimethylammonium). Examples of such etherification agents include dialkyl sulfates, dialkyl carbonates, alkyl halides (e.g., alkyl

chloride), iodoalkanes, alkyl triflates (alkyl trifluoromethanesulfonates) and alkyl fluorosulfonates, where the alkyl group(s) of each of these agents has one or more substitutions with a positively charged group (e.g., substituted ammonium group such as trimethylammonium). Other

5 examples of such etherification agents include dimethyl sulfate, dimethyl carbonate, methyl chloride, iodomethane, methyl triflate and methyl fluorosulfonate, where the methyl group(s) of each of these agents has a substitution with a positively charged group (e.g., substituted ammonium group such as trimethylammonium). Other examples of such etherification

10 agents include diethyl sulfate, diethyl carbonate, ethyl chloride, iodoethane, ethyl triflate and ethyl fluorosulfonate, where the ethyl group(s) of each of these agents has a substitution with a positively charged group (e.g., substituted ammonium group such as trimethylammonium). Other examples of such etherification agents

15 include dipropyl sulfate, dipropyl carbonate, propyl chloride, iodopropane, propyl triflate and propyl fluorosulfonate, where the propyl group(s) of each of these agents has one or more substitutions with a positively charged group (e.g., substituted ammonium group such as trimethylammonium). Other examples of such etherification agents include dibutyl sulfate, dibutyl

20 carbonate, butyl chloride, iodobutane and butyl triflate, where the butyl group(s) of each of these agents has one or more substitutions with a positively charged group (e.g., substituted ammonium group such as trimethylammonium).

An etherification agent alternatively may be one that can etherify

25 the present α -glucan oligomers/polymers with a positively charged organic group, where the carbon chain of the positively charged organic group has a substitution (e.g., hydroxyl group) in addition to a substitution with a positively charged group (e.g., substituted ammonium group such as trimethylammonium). Examples of such etherification agents include

30 hydroxyalkyl halides (e.g., hydroxyalkyl chloride) such as hydroxypropyl halide and hydroxybutyl halide, where a terminal carbon of each of these agents has a substitution with a positively charged group (e.g., substituted ammonium group such as trimethylammonium); an example is 3-chloro-2-hydroxypropyl-trimethylammonium. Other examples of such etherification

agents include alkylene oxides such as propylene oxide (e.g., 1,2-propylene oxide) and butylene oxide (e.g., 1,2-butylene oxide; 2,3-butylene oxide), where a terminal carbon of each of these agents has a substitution with a positively charged group (e.g., substituted ammonium group such as trimethylammonium).

A substituted ammonium group comprised in any of the foregoing etherification agent examples can be a primary, secondary, tertiary, or quaternary ammonium group. Examples of secondary, tertiary and quaternary ammonium groups are represented in structure I, where R₂, R₃ and R₄ each independently represent a hydrogen atom or an alkyl group such as a methyl, ethyl, propyl, or butyl group. Etherification agents herein typically can be provided as a fluoride, chloride, bromide, or iodide salt (where each of the foregoing halides serve as an anion).

When producing the present α -glucan ether compounds with two or more different organic groups, two or more different etherification agents would be used, accordingly. For example, both an alkylene oxide and an alkyl chloride could be used as etherification agents to produce an alkyl hydroxyalkyl α -glucan ether. Any of the etherification agents disclosed herein may therefore be combined to produce α -glucan ether compounds with two or more different organic groups. Such two or more etherification agents may be used in the reaction at the same time, or may be used sequentially in the reaction. When used sequentially, any of the temperature-treatment (e.g., heating) steps disclosed below may optionally be used between each addition. One may choose sequential introduction of etherification agents in order to control the desired DoS of each organic group. In general, a particular etherification agent would be used first if the organic group it forms in the ether product is desired at a higher DoS compared to the DoS of another organic group to be added.

The amount of etherification agent to be contacted with the present α -glucan oligomers/polymers in a reaction under alkaline conditions can be determined based on the DoS required in the α -glucan ether compound being produced. The amount of ether substitution groups on each glucose monomeric unit in α -glucan ether compounds produced herein can be determined using nuclear magnetic resonance (NMR) spectroscopy. The

molar substitution (MS) value for α -glucan has no upper limit. In general, an etherification agent can be used in a quantity of at least about 0.05 mole per mole of α -glucan. There is no upper limit to the quantity of etherification agent that can be used.

5 Reactions for producing α -glucan ether compounds herein can optionally be carried out in a pressure vessel such as a Parr reactor, an autoclave, a shaker tube or any other pressure vessel well known in the art. A reaction herein can optionally be heated following the step of contacting the present α -glucan oligomers/polymers with an etherification
10 agent under alkaline conditions. The reaction temperatures and time of applying such temperatures can be varied within wide limits. For example, a reaction can optionally be maintained at ambient temperature for up to 14 days. Alternatively, a reaction can be heated, with or without reflux, between about 25 °C to about 200 °C (or any integer between 25 and 200
15 °C). Reaction time can be varied correspondingly: more time at a low temperature and less time at a high temperature.

 In certain embodiments of producing carboxymethyl α -glucan ethers, a reaction can be heated to about 55 °C for about 3 hours. Thus, a reaction for preparing a carboxyalkyl α -glucan ether herein can be heated
20 to about 50 °C to about 60 °C (or any integer between 50 and 60 °C) for about 2 hours to about 5 hours, for example. Etherification agents such as a haloacetate (e.g., monochloroacetate) may be used in these embodiments, for example.

 Optionally, an etherification reaction herein can be maintained
25 under an inert gas, with or without heating. As used herein, the term "inert gas" refers to a gas which does not undergo chemical reactions under a set of given conditions, such as those disclosed for preparing a reaction herein.

 All of the components of the reactions disclosed herein can be
30 mixed together at the same time and brought to the desired reaction temperature, whereupon the temperature is maintained with or without stirring until the desired α -glucan ether compound is formed. Alternatively, the mixed components can be left at ambient temperature as described above.

Following etherification, the pH of a reaction can be neutralized.

Neutralization of a reaction can be performed using one or more acids.

The term "neutral pH" as used herein, refers to a pH that is neither substantially acidic or basic (e.g., a pH of about 6-8, or about 6.0, 6.2, 6.4, 5 6.6, 6.8, 7.0, 7.2, 7.4, 7.6, 7.8, or 8.0). Various acids that can be used for this purpose include, but are not limited to, sulfuric, acetic (e.g., glacial acetic), hydrochloric, nitric, any mineral (inorganic) acid, any organic acid, or any combination of these acids.

The present α -glucan ether compounds produced in a reaction 10 herein can optionally be washed one or more times with a liquid that does not readily dissolve the compound. For example, α -glucan ether can typically be washed with alcohol, acetone, aromatics, or any combination of these, depending on the solubility of the ether compound therein (where lack of solubility is desirable for washing). In general, a solvent comprising 15 an organic solvent such as alcohol is preferred for washing an α -glucan ether. The present α -glucan ether product(s) can be washed one or more times with an aqueous solution containing methanol or ethanol, for example. For example, 70-95 wt% ethanol can be used to wash the product. The present α -glucan ether product can be washed with a 20 methanol:acetone (e.g., 60:40) solution in another embodiment.

An α -glucan ether produced in the disclosed reaction can be isolated. This step can be performed before or after neutralization and/or washing steps using a funnel, centrifuge, press filter, or any other method or equipment known in the art that allows removal of liquids from solids. 25 An isolated α -glucan ether product can be dried using any method known in the art, such as vacuum drying, air drying, or freeze drying.

Any of the above etherification reactions can be repeated using an α -glucan ether product as the starting material for further modification. This approach may be suitable for increasing the DoS of an organic group, 30 and/or adding one or more different organic groups to the ether product.

The structure, molecular weight and DoS of the α -glucan ether product can be confirmed using various physiochemical analyses known in the art such as NMR spectroscopy and size exclusion chromatography (SEC).

Personal Care and/or Pharmaceutical Compositions Comprising the
Present Soluble Oligomer/polymer

The present glucan oligomer/polymers and/or the present α -glucan ethers may be used in personal care products. For example, one may be able to use such materials as humectants, hydrocolloids or possibly thickening agents. The present α -glucan oligomers/polymers and/or the present α -glucan ethers may be used in conjunction with one or more other types of thickening agents if desired, such as those disclosed in U.S. Patent No. 8,541,041, the disclosure of which is incorporated herein by reference in its entirety.

Personal care products herein are not particularly limited and include, for example, skin care compositions, cosmetic compositions, antifungal compositions, and antibacterial compositions. Personal care products herein may be in the form of, for example, lotions, creams, pastes, balms, ointments, pomades, gels, liquids, combinations of these and the like. The personal care products disclosed herein can include at least one active ingredient. An active ingredient is generally recognized as an ingredient that causes the intended pharmacological effect.

In certain embodiments, a skin care product can be applied to skin for addressing skin damage related to a lack of moisture. A skin care product may also be used to address the visual appearance of skin (e.g., reduce the appearance of flaky, cracked, and/or red skin) and/or the tactile feel of the skin (e.g., reduce roughness and/or dryness of the skin while improved the softness and subtleness of the skin). A skin care product typically may include at least one active ingredient for the treatment or prevention of skin ailments, providing a cosmetic effect, or for providing a moisturizing benefit to skin, such as zinc oxide, petrolatum, white petrolatum, mineral oil, cod liver oil, lanolin, dimethicone, hard fat, vitamin A, allantoin, calamine, kaolin, glycerin, or colloidal oatmeal, and combinations of these. A skin care product may include one or more natural moisturizing factors such as ceramides, hyaluronic acid, glycerin, squalane, amino acids, cholesterol, fatty acids, triglycerides, phospholipids, glycosphingolipids, urea, linoleic acid, glycosaminoglycans, mucopolysaccharide, sodium lactate, or sodium pyrrolidone carboxylate,

for example. Other ingredients that may be included in a skin care product include, without limitation, glycerides, apricot kernel oil, canola oil, squalane, squalene, coconut oil, corn oil, jojoba oil, jojoba wax, lecithin, olive oil, safflower oil, sesame oil, shea butter, soybean oil, sweet almond
5 oil, sunflower oil, tea tree oil, shea butter, palm oil, cholesterol, cholesterol esters, wax esters, fatty acids, and orange oil.

A personal care product herein can also be in the form of makeup or other product including, but not limited to, a lipstick, mascara, rouge, foundation, blush, eyeliner, lip liner, lip gloss, other cosmetics, sunscreen,
10 sun block, nail polish, mousse, hair spray, styling gel, nail conditioner, bath gel, shower gel, body wash, face wash, shampoo, hair conditioner (leave-in or rinse-out), cream rinse, hair dye, hair coloring product, hair shine product, hair serum, hair anti-frizz product, hair split-end repair product, lip balm, skin conditioner, cold cream, moisturizer, body spray, soap, body
15 scrub, exfoliant, astringent, scruffing lotion, depilatory, permanent waving solution, antidandruff formulation, antiperspirant composition, deodorant, shaving product, pre-shaving product, after-shaving product, cleanser, skin gel, rinse, toothpaste, or mouthwash, for example.

A pharmaceutical product herein can be in the form of an emulsion,
20 liquid, elixir, gel, suspension, solution, cream, capsule, tablet, sachet or ointment, for example. Also, a pharmaceutical product herein can be in the form of any of the personal care products disclosed herein. A pharmaceutical product can further comprise one or more pharmaceutically acceptable carriers, diluents, and/or pharmaceutically
25 acceptable salts. The present α -glucan oligomers/polymers and/or compositions comprising the present α -glucan oligomers/polymers can also be used in capsules, encapsulants, tablet coatings, and as excipients for medicaments and drugs.

30 Enzymatic Synthesis of the Soluble α -Glucan Oligomer/Polymer Composition

Methods are provided to enzymatically produce a soluble α -glucan oligomer/polymer composition. In one embodiment, the method comprises the use of at least one recombinantly produced glucosyltransferase belong

to glucoside hydrolase type 70 (E.C. 2.4.1.-) capable of catalyzing the synthesis of a digestion resistant soluble α -glucan oligomer/polymer composition using sucrose as a substrate. Glycoside hydrolase family 70 enzymes are transglucosidases produced by lactic acid bacteria such as

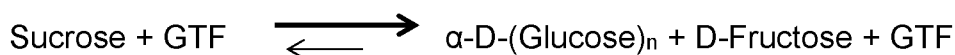
5 *Streptococcus*, *Leuconostoc*, *Weisella* or *Lactobacillus* genera (see Carbohydrate Active Enzymes database; "CAZy"; Cantarel *et al.*, (2009) *Nucleic Acids Res* 37:D233-238). The recombinantly expressed glucosyltransferases preferably have an amino acid sequence identical to that found in nature (*i.e.*, the same as the full length sequence as found in

10 the source organism or a catalytically active truncation thereof).

The GTF enzymes are able to polymerize the D-glucosyl units of sucrose to form homooligosaccharides or homopolysaccharides. Depending upon the specificity of the GTF enzyme, linear and/or branched glucans comprising various glycosidic linkages may be formed such as α -

15 (1,2), α -(1,3), α -(1,4) and α -(1,6). Glucosyltransferases may also transfer the D-glucosyl units onto hydroxyl acceptor groups. A non-limiting list of acceptors may include carbohydrates, alcohols, polyols or flavonoids. The structure of the resultant glucosylated product is dependent upon the enzyme specificity.

20 In the present disclosure, the D-glucopyranosyl donor is sucrose. As such the reaction is:



The type of glycosidic linkage predominantly formed is used to

25 name/classify the glucosyltransferase enzyme. Examples include dextranases (α -(1,6) linkages; EC 2.4.1.5), mutanases (α -(1,3) linkages; EC 2.4.1.-), alternanases (alternating α (1,3)- α (1,6) backbone; EC 2.4.1.140), and reuteranases (mix of α -(1,4) and α -(1,6) linkages; EC 2.4.1.-).

30 In one aspect, the glucosyltransferase (GTF) is capable of forming glucans having 25-35% or more α -(1,3) glycosidic linkages with the proviso that that glucan product is not alternan (*i.e.*, the enzyme is not an alternanase). In a preferred aspect, the glucosyltransferase is a mutanase (EC 2.4.1.-).

In one aspect, the glucosyltransferase comprises an amino acid sequence selected from the group consisting of SEQ ID NOs:10, 12 and combinations thereof (including the mature glucosyltransferases with the signal peptide removed). However, it should be noted that some wild type sequences may be found in nature in a truncated form. As such, and in a further embodiment, the glucosyltransferase suitable for use may be a truncated form of the wild type sequence. In a further embodiment, the truncated glucosyltransferase comprises a sequence derived from the full length wild type amino acid SEQ ID NO: 10. In another embodiment, the glucosyltransferase may be truncated and will have an amino acid sequence SEQ ID NO: 12.

The concentration of the catalyst in the aqueous reaction formulation depends on the specific catalytic activity of the catalyst, and is chosen to obtain the desired rate of reaction. The weight of each catalyst (either a single glucosyltransferase or individually a glucosyltransferase and α -glucanohydrolase) reactions typically ranges from 0.0001 mg to 20 mg per mL of total reaction volume, preferably from 0.001 mg to 10 mg per mL. The catalyst may also be immobilized on a soluble or insoluble support using methods well-known to those skilled in the art; see for example, Immobilization of Enzymes and Cells; Gordon F. Bickerstaff, Editor; Humana Press, Totowa, NJ, USA; 1997. The use of immobilized catalysts permits the recovery and reuse of the catalyst in subsequent reactions. The enzyme catalyst may be in the form of whole microbial cells, permeabilized microbial cells, microbial cell extracts, partially-purified or purified enzymes, and mixtures thereof.

The pH of the final reaction formulation is from about 3 to about 8, preferably from about 4 to about 8, more preferably from about 5 to about 8, even more preferably about 5.5 to about 7.5, and yet even more preferably about 5.5 to about 6.5. The pH of the reaction may optionally be controlled by the addition of a suitable buffer including, but not limited to, phosphate, pyrophosphate, bicarbonate, acetate, or citrate. The concentration of buffer, when employed, is typically from 0.1 mM to 1.0 M, preferably from 1 mM to 300 mM, most preferably from 10 mM to 100 mM.

The sucrose concentration initially present when the reaction components are combined is at least 50 g/L, preferably 50 g/L to 500 g/L, more preferably 100 g/L to 500 g/L, more preferably 150 g/L to 450 g/L, and most preferably 250 g/L to 450 g/L. The substrate for the α -

5 glucanohydrolase (when present) will be the members of the glucose oligomer population formed by the glucosyltransferase. As the glucose oligomers present in the reaction system may act as acceptors, the exact concentration of each species present in the reaction system will vary. Additionally, other acceptors may be added (*i.e.*, external acceptors) to the
10 initial reaction mixture such as maltose, isomaltose, isomaltotriose, and methyl- α -D-glucan, to name a few.

The length of the reaction may vary and may often be determined by the amount of time it takes to use all of the available sucrose substrate. In one embodiment, the reaction is conducted until at least 90%,
15 preferably at least 95% and most preferably at least 99% of the sucrose initially present in the reaction mixture is consumed. In another embodiment, the reaction time is 1 hour to 168 hours, preferably 1 hour to 120 hours, and most preferably 1 hour to 72 hours.

20 *Soluble Glucan Fiber Synthesis – Reaction Systems Comprising a Glucosyltransferase (Gtf) and an α -Glucanohydrolase*

A method is provided to enzymatically produce the present soluble glucan oligomer/polymers using at least one α -glucanohydrolase in
25 combination (*i.e.*, concomitantly in the reaction mixture) with at least one of the above glucosyltransferases. The simultaneous use of the two enzymes produces a different product profile (*i.e.*, the profile of the soluble oligomer/polymer composition) when compared to a sequential application of the same enzymes (*i.e.*, first synthesizing the glucan polymer from
30 sucrose using a glucosyltransferase and then subsequently treating the glucan polymer with an α -glucanohydrolase). In one embodiment, a glucan oligomer/polymer synthesis method based on sequential application of a glucosyltransferase with an α -glucanohydrolase is specifically excluded.

Similar to the glucosyltransferases, an α -glucanohydrolase may be defined by the endohydrolysis activity towards certain α -D-glycosidic linkages. Examples may include, but are not limited to, dextranases (capable of hydrolyzing α -(1,6)-linked glycosidic bonds; E.C. 3.2.1.11),
5 mutanases (capable of hydrolyzing α -(1,3)-linked glycosidic bonds; E.C. 3.2.1.59), mycodextranases (capable of endohydrolysis of (1 \rightarrow 4)- α -D-glucosidic linkages in α -D-glucans containing both (1 \rightarrow 3)- and (1 \rightarrow 4)-bonds; EC 3.2.1.61), glucan 1,6- α -glucosidase (EC 3.2.1.70), and alternanases (capable of endohydrolytically cleaving alternan; E.C. 3.2.1.-;
10 see U.S. 5,786,196). Various factors including, but not limited to, level of branching, the type of branching, and the relative branch length within certain α -glucans may adversely impact the ability of an α -glucanohydrolase to endohydrolyze some glycosidic linkages.

In one embodiment, the α -glucanohydrolase is a dextranase (EC
15 2.1.1.11), a mutanase (EC 3.1.1.59) or a combination thereof. In one embodiment, the dextranase is a food grade dextranase from *Chaetomium erraticum*. In a further embodiment, the dextranase from *Chaetomium erraticum* is DEXTRANASE® PLUS L, available from Novozymes A/S, Denmark.

20 In another embodiment, the α -glucanohydrolase is at least one mutanase (EC 3.1.1.59). In one embodiment, the mutanase is one obtainable from the genera *Penicillium*, *Paenibacillus*, *Hypocrea*, *Aspergillus*, and *Trichoderma*. In a further embodiment, the mutanase is from *Penicillium marneffe* ATCC 18224 or *Paenibacillus Humicus*. In one
25 embodiment, the polypeptide having mutanase activity comprises at least 90% identity, preferably 91, 92, 93, 94, 95, 96, 97, 98, 99 or 100% identity, to at least one of the mutanase sequences described herein. In one embodiment, the polypeptide having mutanase activity comprises at least 90% identity, preferably 91, 92, 93, 94, 95, 96, 97, 98, 99 or 100% identity,
30 to SEQ ID NO: 1, 3, 6 or 8. In one embodiment, the mutanase comprises an amino acid sequence selected from SEQ ID NOs 1, 3, 6, 8 and any combination thereof when used in combination with the above glucosyltransferases. In yet a further embodiment, the mutanase comprises an amino acid sequence selected from SEQ ID NO: 1, 3, 6, and

any combination thereof. In a further embodiment, the mutanase comprises SEQ ID NO: 3. In another embodiment, the above mutanases may be a catalytically active truncation so long as the mutanase activity is retained

- 5 The temperature of the enzymatic reaction system comprising concomitant use of at least one glucosyltransferase and at least one α -glucanohydrolase may be chosen to control both the reaction rate and the stability of the enzyme catalyst activity. The temperature of the reaction may range from just above the freezing point of the reaction formulation
- 10 (approximately 0 °C) to about 60 °C, with a preferred range of 5 °C to about 55 °C, and a more preferred range of reaction temperature of from about 20 °C to about 45 °C.

- The ratio of glucosyltransferase activity to α -glucanohydrolase activity may vary depending upon the selected enzymes. In one
- 15 embodiment, the ratio of glucosyltransferase activity to α -glucanohydrolase activity ranges from 1:0.01 to 0.01:1.0.

 In one embodiment, a method is provided to produce a soluble α -glucan oligomer/polymer composition comprising:

- a. providing a set of reaction components comprising:
- 20 i. sucrose;
- ii. at least one polypeptide having glucosyltransferase activity; said polypeptide having at least 90% identity to SEQ ID NO: 10 or 12;
- iii. at least one polypeptide having α -glucanohydrolase
- 25 activity; said polypeptide selected from the group of:
1. a polypeptide having mutanase activity, said polypeptide having at least 90% identity to SEQ ID NO: 1 or 3;
2. a polypeptide comprising dextranase activity; and
- 30 3. a combination of 1 and 2.; and
- iv. optionally one more acceptors;
- b. combining under suitable reaction conditions the set of reaction components of (a) whereby a product comprising a soluble α -glucan oligomer/polymer composition is produced; and

- c. optionally isolating the soluble α -glucan oligomer/polymer composition from the product of step (b).

In a preferred embodiment, the at least one glucosyltransferase and the at least one α -glucanohydrolase are concomitantly present in the
5 reaction to produce the soluble α -glucan oligomer/polymer composition.

Methods to Identify Substantially Similar Enzymes Having the Desired Activity

10 The skilled artisan recognizes that substantially similar enzyme sequences may also be used in the present compositions and methods so long as the desired activity is retained (*i.e.*, glucosyltransferase activity capable of forming glucans having the desired glycosidic linkages or α -
15 glycosidic linkage(s)). For example, it has been demonstrated that catalytically activity truncations may be prepared and used so long as the desired activity is retained (or even improved in terms of specific activity). In one embodiment, substantially similar sequences are defined by their ability to hybridize, under highly stringent conditions with the nucleic acid
20 molecules associated with sequences exemplified herein. In another embodiment, sequence alignment algorithms may be used to define substantially similar enzymes based on the percent identity to the DNA or amino acid sequences provided herein.

As used herein, a nucleic acid molecule is "hybridizable" to another
25 nucleic acid molecule, such as a cDNA, genomic DNA, or RNA, when a single strand of the first molecule can anneal to the other molecule under appropriate conditions of temperature and solution ionic strength. Hybridization and washing conditions are well known and exemplified in Sambrook, J. and Russell, D., T. Molecular Cloning: A Laboratory Manual,
30 Third Edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor (2001). The conditions of temperature and ionic strength determine the "stringency" of the hybridization. Stringency conditions can be adjusted to screen for moderately similar molecules, such as homologous sequences from distantly related organisms, to highly similar molecules, such as

genes that duplicate functional enzymes from closely related organisms.

Post-hybridization washes typically determine stringency conditions. One set of preferred conditions uses a series of washes starting with 6X SSC,

0.5% SDS at room temperature for 15 min, then repeated with 2X SSC,

5 0.5% SDS at 45°C for 30 min, and then repeated twice with 0.2X SSC,

0.5% SDS at 50°C for 30 min. A more preferred set of conditions uses

higher temperatures in which the washes are identical to those above

except for the temperature of the final two 30 min washes in 0.2X SSC,

0.5% SDS was increased to 60°C. Another preferred set of highly

10 stringent hybridization conditions is 0.1X SSC, 0.1% SDS, 65°C and

washed with 2X SSC, 0.1% SDS followed by a final wash of 0.1X SSC,

0.1% SDS, 65°C.

Hybridization requires that the two nucleic acids contain

complementary sequences, although depending on the stringency of the

15 hybridization, mismatches between bases are possible. The appropriate

stringency for hybridizing nucleic acids depends on the length of the

nucleic acids and the degree of complementation, variables well known in

the art. The greater the degree of similarity or homology between two

nucleotide sequences, the greater the value of T_m for hybrids of nucleic

20 acids having those sequences. The relative stability (corresponding to

higher T_m) of nucleic acid hybridizations decreases in the following order:

RNA:RNA, DNA:RNA, DNA:DNA. For hybrids of greater than

100 nucleotides in length, equations for calculating T_m have been derived

(Sambrook, J. and Russell, D., T., *supra*). For hybridizations with shorter

25 nucleic acids, *i.e.*, oligonucleotides, the position of mismatches becomes

more important, and the length of the oligonucleotide determines its

specificity. In one aspect, the length for a hybridizable nucleic acid is at

least about 10 nucleotides. Preferably, a minimum length for a

hybridizable nucleic acid is at least about 15 nucleotides in length, more

30 preferably at least about 20 nucleotides in length, even more preferably at

least 30 nucleotides in length, even more preferably at least 300

nucleotides in length, and most preferably at least 800 nucleotides in

length. Furthermore, the skilled artisan will recognize that the temperature

and wash solution salt concentration may be adjusted as necessary according to factors such as length of the probe.

As used herein, the term “percent identity” is a relationship between two or more polypeptide sequences or two or more polynucleotide sequences, as determined by comparing the sequences. In the art, “identity” also means the degree of sequence relatedness between polypeptide or polynucleotide sequences, as the case may be, as determined by the match between strings of such sequences. “Identity” and “similarity” can be readily calculated by known methods, including but not limited to those described in: Computational Molecular Biology (Lesk, A. M., ed.) Oxford University Press, NY (1988); Biocomputing: Informatics and Genome Projects (Smith, D. W., ed.) Academic Press, NY (1993); Computer Analysis of Sequence Data, Part I (Griffin, A. M., and Griffin, H. G., eds.) Humana Press, NJ (1994); Sequence Analysis in Molecular Biology (von Heinje, G., ed.) Academic Press (1987); and Sequence Analysis Primer (Gribskov, M. and Devereux, J., eds.) Stockton Press, NY (1991). Methods to determine identity and similarity are codified in publicly available computer programs. Sequence alignments and percent identity calculations may be performed using the Megalign program of the LASERGENE bioinformatics computing suite (DNASTAR Inc., Madison, WI), the AlignX program of Vector NTI v. 7.0 (Informax, Inc., Bethesda, MD), or the EMBOSS Open Software Suite (EMBL-EBI; Rice *et al.*, *Trends in Genetics* 16, (6):276-277 (2000)). Multiple alignment of the sequences can be performed using the CLUSTAL method (such as CLUSTALW; for example version 1.83) of alignment (Higgins and Sharp, *CABIOS*, 5:151-153 (1989); Higgins *et al.*, *Nucleic Acids Res.* 22:4673-4680 (1994); and Chenna *et al.*, *Nucleic Acids Res* 31 (13):3497-500 (2003)), available from the European Molecular Biology Laboratory via the European Bioinformatics Institute) with the default parameters. Suitable parameters for CLUSTALW protein alignments include GAP Existence penalty=15, GAP extension =0.2, matrix = Gonnet (e.g., Gonnet250), protein ENDGAP = -1, protein GAPDIST=4, and KTUPLE=1. In one embodiment, a fast or slow alignment is used with the default settings where a slow alignment is preferred. Alternatively, the parameters using

the CLUSTALW method (e.g., version 1.83) may be modified to also use KTUPLE =1, GAP PENALTY=10, GAP extension =1, matrix = BLOSUM (e.g., BLOSUM64), WINDOW=5, and TOP DIAGONALS SAVED=5.

5 In one aspect, suitable isolated nucleic acid molecules encode a polypeptide having an amino acid sequence that is at least about 20%, preferably at least 30%, 40%, 50%, 60%, 70%, 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequences reported herein. In another aspect, suitable isolated nucleic acid molecules encode a polypeptide having an amino acid sequence that
10 is at least about 20%, preferably at least 30%, 40%, 50%, 60%, 70%, 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identical to the amino acid sequences reported herein; with the proviso that the polypeptide retains the respective activity (*i.e.*, glucosyltransferase or α -glucanohydrolase activity).

15

Methods to Obtain the Enzymatically-Produced Soluble α -Glucan Oligomer/Polymer Composition

Any number of common purification techniques may be used to obtain the present soluble α -glucan oligomer/polymer composition from
20 the reaction system including, but not limited to centrifugation, filtration, fractionation, chromatographic separation, dialysis, evaporation, precipitation, dilution or any combination thereof, preferably by dialysis or chromatographic separation, most preferably by dialysis (ultrafiltration).

25 Recombinant Microbial Expression

The genes and gene products of the instant sequences may be produced in heterologous host cells, particularly in the cells of microbial hosts. Preferred heterologous host cells for expression of the instant genes and nucleic acid molecules are microbial hosts that can be found
30 within the fungal or bacterial families and which grow over a wide range of temperature, pH values, and solvent tolerances. For example, it is contemplated that any of bacteria, yeast, and filamentous fungi may suitably host the expression of the present nucleic acid molecules. The enzyme(s) may be expressed intracellularly, extracellularly, or a

combination of both intracellularly and extracellularly, where extracellular expression renders recovery of the desired protein from a fermentation product more facile than methods for recovery of protein produced by intracellular expression. Transcription, translation and the protein biosynthetic apparatus remain invariant relative to the cellular feedstock used to generate cellular biomass; functional genes will be expressed regardless. Examples of host strains include, but are not limited to, bacterial, fungal or yeast species such as *Aspergillus*, *Trichoderma*, *Saccharomyces*, *Pichia*, *Phaffia*, *Kluyveromyces*, *Candida*, *Hansenula*, *Yarrowia*, *Salmonella*, *Bacillus*, *Acinetobacter*, *Zymomonas*, *Agrobacterium*, *Erythrobacter*, *Chlorobium*, *Chromatium*, *Flavobacterium*, *Cytophaga*, *Rhodobacter*, *Rhodococcus*, *Streptomyces*, *Brevibacterium*, *Corynebacteria*, *Mycobacterium*, *Deinococcus*, *Escherichia*, *Erwinia*, *Pantoea*, *Pseudomonas*, *Sphingomonas*, *Methylomonas*, *Methylobacter*, *Methylococcus*, *Methylosinus*, *Methylomicrobium*, *Methylocystis*, *Alcaligenes*, *Synechocystis*, *Synechococcus*, *Anabaena*, *Thiobacillus*, *Methanobacterium*, *Klebsiella*, and *Myxococcus*. In one embodiment, the fungal host cell is *Trichoderma*, preferably a strain of *Trichoderma reesei*. In one embodiment, bacterial host strains include *Escherichia*, *Bacillus*, *Kluyveromyces*, and *Pseudomonas*. In a preferred embodiment, the bacterial host cell is *Bacillus subtilis* or *Escherichia coli*.

Large-scale microbial growth and functional gene expression may use a wide range of simple or complex carbohydrates, organic acids and alcohols or saturated hydrocarbons, such as methane or carbon dioxide in the case of photosynthetic or chemoautotrophic hosts, the form and amount of nitrogen, phosphorous, sulfur, oxygen, carbon or any trace micronutrient including small inorganic ions. The regulation of growth rate may be affected by the addition, or not, of specific regulatory molecules to the culture and which are not typically considered nutrient or energy sources.

Vectors or cassettes useful for the transformation of suitable host cells are well known in the art. Typically the vector or cassette contains sequences directing transcription and translation of the relevant gene, a selectable marker, and sequences allowing autonomous replication or

chromosomal integration. Suitable vectors comprise a region 5' of the gene which harbors transcriptional initiation controls and a region 3' of the DNA fragment which controls transcriptional termination. It is most preferred when both control regions are derived from genes homologous to the transformed host cell and/or native to the production host, although such control regions need not be so derived.

Initiation control regions or promoters which are useful to drive expression of the present cephalosporin C deacetylase coding region in the desired host cell are numerous and familiar to those skilled in the art. Virtually any promoter capable of driving these genes is suitable including but not limited to, *CYC1*, *HIS3*, *GAL1*, *GAL10*, *ADH1*, *PGK*, *PHO5*, *GAPDH*, *ADC1*, *TRP1*, *URA3*, *LEU2*, *ENO*, *TPI* (useful for expression in *Saccharomyces*); *AOX1* (useful for expression in *Pichia*); and *lac*, *araB*, *tet*, *trp*, *IP_L*, *IP_R*, *T7*, *tac*, and *trc* (useful for expression in *Escherichia coli*) as well as the *amy*, *apr*, *npr* promoters and various phage promoters useful for expression in *Bacillus*.

Termination control regions may also be derived from various genes native to the preferred host cell. In one embodiment, the inclusion of a termination control region is optional. In another embodiment, the chimeric gene includes a termination control region derived from the preferred host cell.

Industrial Production

A variety of culture methodologies may be applied to produce the enzyme(s). For example, large-scale production of a specific gene product over-expressed from a recombinant microbial host may be produced by batch, fed-batch, and continuous culture methodologies. Batch and fed-batch culturing methods are common and well known in the art and examples may be found in Biotechnology: A Textbook of Industrial Microbiology by Wulf Crueger and Anneliese Crueger (authors), Second Edition, (Sinauer Associates, Inc., Sunderland, MA (1990) and Manual of Industrial Microbiology and Biotechnology, Third Edition, Richard H. Baltz,

Arnold L. Demain, and Julian E. Davis (Editors), (ASM Press, Washington, DC (2010).

Commercial production of the desired enzyme(s) may also be accomplished with a continuous culture. Continuous cultures are an open system where a defined culture media is added continuously to a bioreactor and an equal amount of conditioned media is removed simultaneously for processing. Continuous cultures generally maintain the cells at a constant high liquid phase density where cells are primarily in log phase growth. Alternatively, continuous culture may be practiced with immobilized cells where carbon and nutrients are continuously added and valuable products, by-products or waste products are continuously removed from the cell mass. Cell immobilization may be performed using a wide range of solid supports composed of natural and/or synthetic materials.

Recovery of the desired enzyme(s) from a batch fermentation, fed-batch fermentation, or continuous culture, may be accomplished by any of the methods that are known to those skilled in the art. For example, when the enzyme catalyst is produced intracellularly, the cell paste is separated from the culture medium by centrifugation or membrane filtration, optionally washed with water or an aqueous buffer at a desired pH, then a suspension of the cell paste in an aqueous buffer at a desired pH is homogenized to produce a cell extract containing the desired enzyme catalyst. The cell extract may optionally be filtered through an appropriate filter aid such as celite or silica to remove cell debris prior to a heat-treatment step to precipitate undesired protein from the enzyme catalyst solution. The solution containing the desired enzyme catalyst may then be separated from the precipitated cell debris and protein by membrane filtration or centrifugation, and the resulting partially-purified enzyme catalyst solution concentrated by additional membrane filtration, then optionally mixed with an appropriate carrier (for example, maltodextrin, phosphate buffer, citrate buffer, or mixtures thereof) and spray-dried to produce a solid powder comprising the desired enzyme catalyst. Alternatively, the resulting partially-purified enzyme catalyst solution can be stabilized as a liquid formulation by the addition of polyols such as

maltodextrin, sorbitol, or propylene glycol, to which is optionally added a preservative such as sorbic acid, sodium sorbate or sodium benzoate.

When an amount, concentration, or other value or parameter is given either as a range, preferred range, or a list of upper preferable values and lower preferable values, this is to be understood as specifically disclosing all ranges formed from any pair of any upper range limit or preferred value and any lower range limit or preferred value, regardless of whether ranges are separately disclosed. Where a range of numerical values is recited herein, unless otherwise stated, the range is intended to include the endpoints thereof, and all integers and fractions within the range. It is not intended that the scope be limited to the specific values recited when defining a range.

Description of Certain Embodiments

- 15 In a first embodiment (the "first embodiment"), a soluble α -glucan oligomer/polymer composition is provided, said soluble α -glucan oligomer/polymer composition comprising:
- a. 25-35 α -(1,3) glycosidic linkages, preferably 27-31% α -(1,3) glycosidic linkages;
 - 20 b. 55-75% α -(1,6) glycosidic linkages; preferable 55-65%, more preferably 57-61% α -(1,6) glycosidic linkages;
 - c. 5-15% α -(1,3,6) glycosidic linkages; preferably 7-11% α -(1,3,6) glycosidic linkages;
 - d. a weight average molecular weight of less than 5000 Daltons; preferably less than 2500 Daltons, more preferably between 500 and 2500 Daltons, and most preferably about 500 to about 2000 Daltons;
 - 25 e. a viscosity of less than 250 cP (0.25 Pascal second (Pa•s)), preferably less than 10 cP (0.01 (Pa•s)), preferably less than 7 cP (0.007 Pa•s), more preferably less than 5 cP (0.005 Pa•s), more preferably less than 4 cP (0.004 Pa•s), and most preferably less than 3 cP (0.003 Pa•s) at 12 wt% in water at 20 °C.
 - 30

- f. a solubility of at least 20% (w/w), preferably at least 30%, 40%, 50%, 60%, or 70%, in water at 25 °C; and
- g. a polydispersity index of less than 5.

In second embodiment, a fabric care, laundry care, or aqueous
5 composition is provided comprising 0.01 to 99 wt% (dry solids basis), preferably 10 to 90% wt%, of the soluble α -glucan oligomer/polymer composition described above.

In another embodiment, a method to produce a soluble α -glucan oligomer/polymer composition is provided comprising:

- 10 a. providing a set of reaction components comprising:
 - i. sucrose; preferably at an initial concentration of at least 50 g/L, more preferably at least 200 g/L;
 - ii. at least one polypeptide having glucosyltransferase activity; said polypeptide having at least 90% identity, preferably 91,
15 92, 93, 94, 95, 96, 97, 98, 99 or 100% identity to SEQ ID NO: 10 or 12;
 - iii. at least one polypeptide having α -glucanohydrolase activity; said polypeptide selected from the group of:
 - 1. a polypeptide having mutanase activity, said
20 polypeptide having at least 90% identity, preferably at least 91, 92, 93, 94, 95, 96, 97, 98, 99 or 100% identity to SEQ ID NO: 1, 3, 6 or 8;
 - 2. a polypeptide comprising dextranase activity; preferably dextranase activity from *Chaetomium erraticum*;
25 more preferably dextranase L from *Chaetomium erraticum*; and
 - 3. a combination of 1 and 2.; and
 - iv. optionally one more acceptors;
- b. combining under suitable reaction conditions the set of
30 reaction components of (a) whereby a product comprising a soluble α -glucan oligomer/polymer composition is produced; preferably wherein the polypeptide having glucosyltransferase activity and the polypeptide having α -glucanohydrolase activity are concomitantly present in the reaction mixture; and

c. optionally isolating the soluble α -glucan oligomer/polymer composition from the product of step (b).; preferably wherein the isolating step (c) is present.

5 In another embodiment, the above method is used to produce the α -glucan oligomer/polymer composition of the first embodiment.

A composition or method according to any of the above embodiments wherein the soluble α -glucan oligomer/polymer composition comprises less than 4%, preferably less than 2%, more preferably less than 1 %, and most preferably less than 0.5 % α -(1,4) glycosidic linkages.

10 A composition or method according to any of the above embodiments wherein the soluble α -glucan oligomer/polymer composition is characterized by a number average molecular weight (M_n) between 400 and 2500 g/mol.

15 A composition or method according to any of the above embodiments wherein the α -glucanohydrolase is an endomutanase and the glucosyltransferase is a mutansucrase.

20 A composition comprising 0.01 to 99 wt % (dry solids basis) of the present soluble α -glucan oligomer/polymer composition and at least one of the following ingredients: at least one cellulase, at least one protease or a combination thereof.

A method according to any of the above embodiments wherein the isolating step comprises at least one of centrifugation, filtration, fractionation, chromatographic separation, dialysis, evaporation, dilution or any combination thereof.

25 A method according to any of the above embodiments wherein the ratio of glucosyltransferase activity to α -glucanohydrolase activity ranges from 0.01:1 to 1:0.01.

30 A method according to any of the above embodiments wherein the suitable reaction conditions (for enzymatic glucan synthesis) comprises a reaction temperature between 0 °C and 45 °C.

A method according to any of the above embodiments wherein the suitable reaction conditions comprise a pH range of 3 to 8, preferably 4 to 8.

A method according to any of the above embodiments wherein a buffer is present and is selected from the group consisting of phosphate, pyrophosphate, bicarbonate, acetate, or citrate.

5 A method according to any of the above embodiments wherein said at least one glucosyltransferase and said at least one α -glucanohydrolase is selected from the combinations of:

- 1) glucosyltransferase GTF4154 (SEQ ID NO: 10, 12 or a combination thereof) and mutanase MUT3264 (SEQ ID NO: 1, 3, 6 or a combination thereof) and
- 10 2) glucosyltransferase GTF4154 (SEQ ID NO: 10, 12 or a combination thereof) and dextranase; preferably a *Chaetomium erraticum* dextranase.

A product produced by any of the above process embodiments; preferably wherein the product produced is the soluble α -glucan
15 oligomer/polymer composition of the first embodiment.

EXAMPLES

Unless defined otherwise herein, all technical and scientific terms used herein have the same meaning as commonly understood by one of
20 ordinary skill in the art to which this disclosure belongs. Singleton, *et al.*, DICTIONARY OF MICROBIOLOGY AND MOLECULAR BIOLOGY, 2D ED., John Wiley and Sons, New York (1994), and Hale & Marham, THE HARPER COLLINS DICTIONARY OF BIOLOGY, Harper Perennial, N.Y. (1991) provide one of skill with a general dictionary of many of the terms
25 used in this disclosure.

The present disclosure is further defined in the following Examples. It should be understood that these Examples, while indicating preferred embodiments of the disclosure, are given by way of illustration only. From the above discussion and these Examples, one skilled in the art can
30 ascertain the essential characteristics, and without departing from the spirit and scope thereof, can make various changes and modifications to adapt it to various uses and conditions.

The meaning of abbreviations is as follows: "sec" or "s" means second(s), "ms" mean milliseconds, "min" means minute(s), "h" or "hr"

means hour(s), "μL" means microliter(s), "mL" means milliliter(s), "L" means liter(s); "mL/min" is milliliters per minute; "μg/mL" is microgram(s) per milliliter(s); "LB" is Luria broth; "μm" is micrometers, "nm" is nanometers; "OD" is optical density; "IPTG" is isopropyl-β-D-thio-galactoside; "g" is gravitational force; "mM" is millimolar; "SDS-PAGE" is sodium dodecyl sulfate polyacrylamide; "mg/mL" is milligrams per milliliters; "N" is normal; "w/v" is weight for volume; "DTT" is dithiothreitol; "BCA" is bicinchoninic acid; "DMAc" is N, N'-dimethyl acetamide; "LiCl" is Lithium chloride; "NMR" is nuclear magnetic resonance; "DMSO" is dimethylsulfoxide; "SEC" is size exclusion chromatography; "GI" or "gi" means GenInfo Identifier, a system used by GENBANK® and other sequence databases to uniquely identify polynucleotide and/or polypeptide sequences within the respective databases; "DPx" means glucan degree of polymerization having "x" units in length; "ATCC" means American Type Culture Collection (Manassas, VA), "DSMZ" and "DSM" will refer to Leibniz Institute DSMZ-German Collection of Microorganisms and Cell Cultures, (Braunschweig, Germany); "EELA" is the Finish Food Safety Authority (Helsinki, Finland); "CCUG" refer to the Culture Collection, University of Göteborg, Sweden; "Suc." means sucrose; "Gluc." means glucose; "Fruc." means fructose; "Leuc." means leucrose; and "Rxn" means reaction.

General Methods

Standard recombinant DNA and molecular cloning techniques used herein are well known in the art and are described by Sambrook, J. and Russell, D., Molecular Cloning: A Laboratory Manual, Third Edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY (2001); and by Silhavy, T. J., Bennis, M. L. and Enquist, L. W., Experiments with Gene Fusions, Cold Spring Harbor Laboratory Cold Press Spring Harbor, NY (1984); and by Ausubel, F. M. et. al., Short Protocols in Molecular Biology, 5th Ed. Current Protocols and John Wiley and Sons, Inc., N.Y., 2002.

Materials and methods suitable for the maintenance and growth of bacterial cultures are also well known in the art. Techniques suitable for

use in the following Examples may be found in Manual of Methods for General Bacteriology, Philipp Gerhardt, R. G. E. Murray, Ralph N. Costilow, Eugene W. Nester, Willis A. Wood, Noel R. Krieg and G. Briggs Phillips, eds., (American Society for Microbiology Press, Washington, DC (1994)), Biotechnology: A Textbook of Industrial Microbiology by Wulf Crueger and Anneliese Crueger (authors), Second Edition, (Sinauer Associates, Inc., Sunderland, MA (1990)), and Manual of Industrial Microbiology and Biotechnology, Third Edition, Richard H. Baltz, Arnold L. Demain, and Julian E. Davis (Editors), (American Society of Microbiology Press, Washington, DC (2010)).

All reagents, restriction enzymes and materials used for the growth and maintenance of bacterial cells were obtained from BD Diagnostic Systems (Sparks, MD), Invitrogen/Life Technologies Corp. (Carlsbad, CA), Life Technologies (Rockville, MD), QIAGEN (Valencia, CA), Sigma-Aldrich Chemical Company (St. Louis, MO) or Pierce Chemical Co. (A division of Thermo Fisher Scientific Inc., Rockford, IL) unless otherwise specified. IPTG, (cat#I6758) and triphenyltetrazolium chloride were obtained from the Sigma Co., (St. Louis, MO). Bellco spin flask was from the Bellco Co., (Vineland, NJ). LB medium was from Becton, Dickinson and Company (Franklin Lakes, New Jersey). BCA protein assay was from Sigma-Aldrich (St Louis, MO).

Growth of Recombinant *E. coli* Strains for Production of GTF Enzymes

Escherichia coli strains expressing a functional GTF enzyme were grown in shake flask using LB medium with ampicillin (100 µg/mL) at 37 °C and 220 rpm to OD_{600nm} = 0.4 - 0.5, at which time isopropyl-β-D-thiogalactoside (IPTG) was added to a final concentration of 0.5 mM and incubation continued for 2-4 hr at 37 °C. Cells were harvested by centrifugation at 5,000 x g for 15 min and resuspended (20%-25% wet cell weight/v) in 50 mM phosphate buffer pH 7.0). Resuspended cells were passed through a French Pressure Cell (SLM Instruments, Rochester, NY) twice to ensure >95% cell lysis. Cell lysate was centrifuged for 30 min at 12,000 x g and 4 °C. The resulting supernatant (cell extract) was analyzed

by the BCA protein assay and SDS-PAGE to confirm expression of the GTF enzyme, and the cell extract was stored at -80 °C.

pHYT Vector

- 5 The pHYT vector backbone is a replicative *Bacillus subtilis* expression plasmid containing the *Bacillus subtilis aprE* promoter. It was derived from the *Escherichia coli-Bacillus subtilis* shuttle vector pHY320PLK (GENBANK® Accession No. D00946 and is commercially available from Takara Bio Inc. (Otsu, Japan)). The replication origin for
- 10 *Escherichia coli* and ampicillin resistance gene are from pACYC177 (GENBANK® X06402 and is commercially available from New England Biolabs Inc., Ipswich, MA). The replication origin for *Bacillus subtilis* and tetracycline resistance gene were from pAMalpha-1 (Francia *et al.*, *J Bacteriol.* 2002 Sep;184(18):5187-93)).
- 15 To construct pHYT, a terminator sequence: 5'-ATAAAAAACGCTCGGTTGCCGCCGGGCGTTTTTTAT-3' (SEQ ID NO: 13) from phage lambda was inserted after the tetracycline resistance gene. The entire expression cassette (EcoRI-BamHI fragment) containing the
- 20 *aprE* promoter –AprE signal peptide sequence-coding sequence encoding the enzyme of interest (*e.g.*, coding sequences for various GTFs)-*BPN'* terminator was cloned into the EcoRI and HindIII sites of pHYT using a BamHI-HindIII linker that destroyed the HindIII site. The linker sequence is 5'-GGATCCTGACTGCCTGAGCTT-3' (SEQ ID NO: 14). The *aprE*
- 25 promoter and AprE signal peptide sequence (SEQ ID NO: 4) are native to *Bacillus subtilis*. The *BPN'* terminator is from subtilisin of *Bacillus amyloliquefaciens*. In the case when native signal peptide was used, the AprE signal peptide was replaced with the native signal peptide of the expressed gene.

30

Biolistic transformation of *T. reesei*

A *Trichoderma reesei* spore suspension was spread onto the center ~6 cm diameter of an acetamidase transformation plate (150 µL of a 5x10⁷- 5x10⁸ spore/mL suspension). The plate was then air dried in a

biological hood. The stopping screens (BioRad 165-2336) and the macrocarrier holders (BioRad 1652322) were soaked in 70% ethanol and air dried. DRIERITE® desiccant (calcium sulfate desiccant; W.A. Hammond DRIERITE® Company, Xenia, OH) was placed in small Petri dishes (6 cm Pyrex) and overlaid with Whatman filter paper (GE Healthcare Bio-Sciences, Pittsburgh, PA). The macrocarrier holder containing the macrocarrier (BioRad 165-2335; Bio-Rad Laboratories, Hercules, CA) was placed flatly on top of the filter paper and the Petri dish lid replaced. A tungsten particle suspension was prepared by adding 60 mg tungsten M-10 particles (microcarrier, 0.7 micron, BioRad #1652266, Bio-Rad Laboratories) to an Eppendorf tube. Ethanol (1 mL) (100%) was added. The tungsten was vortexed in the ethanol solution and allowed to soak for 15 minutes. The Eppendorf tube was microfuged briefly at maximum speed to pellet the tungsten. The ethanol was decanted and washed three times with sterile distilled water. After the water wash was decanted the third time, the tungsten was resuspended in 1 mL of sterile 50% glycerol. The transformation reaction was prepared by adding 25 µL suspended tungsten to a 1.5 mL-Eppendorf tube for each transformation. Subsequent additions were made in order, 2 µL DNA pTrex3 expression vectors (SEQ ID NO: 9; see U.S. Pat. No. 6,426,410), 25 µL 2.5 M CaCl₂, 10 µL 0.1M spermidine. The reaction was vortexed continuously for 5-10 minutes, keeping the tungsten suspended. The Eppendorf tube was then microfuged briefly and decanted. The tungsten pellet was washed with 200 µL of 70% ethanol, microfuged briefly to pellet and decanted. The pellet was washed with 200 µL of 100% ethanol, microfuged briefly to pellet, and decanted. The tungsten pellet was resuspended in 24 µL 100% ethanol. The Eppendorf tube was placed in an ultrasonic water bath for 15 seconds and 8 µL aliquots were transferred onto the center of the desiccated macrocarriers. The macrocarriers were left to dry in the desiccated Petri dishes.

A Helium tank was turned on to 1500 psi (~ 10.3 MPa). 1100 psi (~7.58 MPa) rupture discs (BioRad 165-2329) were used in the Model PDS-1000/He™ BIOLISTIC® Particle Delivery System (BioRad). When the tungsten solution was dry, a stopping screen and the macrocarrier holder

- were inserted into the PDS-1000. An acetamidase plate, containing the target *T. reesei* spores, was placed 6 cm below the stopping screen. A vacuum of 29 inches Hg (~ 98.2 kPa) was pulled on the chamber and held. The He BIOLISTIC® Particle Delivery System was fired. The
- 5 chamber was vented and the acetamidase plate removed for incubation at 28 °C until colonies appeared (5 days).

Modified *amdS* Biolistic agar (MABA) per liter

Part I, make in 500 mL distilled water (dH₂O)

- 10 1000x salts 1 mL
Noble agar 20 g
pH to 6.0, autoclave

Part II, make in 500 mL dH₂O

- 15 Acetamide 0.6 g
CsCl 1.68 g
Glucose 20 g
KH₂PO₄ 15 g
MgSO₄·7H₂O 0.6 g
20 CaCl₂·2H₂O 0.6 g
pH to 4.5, 0.2 micron filter sterilize; leave in 50 °C oven to warm, add to agar, mix, pour plates. Stored at room temperature (~ 21 °C)

1000x Salts per liter

- FeSO₄·7H₂O 5 g
25 MnSO₄·H₂O 1.6 g
ZnSO₄·7H₂O 1.4 g
CoCl₂·6H₂O 1 g
Bring up to 1L dH₂O.
0.2 micron filter sterilize

30

Determination of the Glucosyltransferase Activity

Glucosyltransferase activity assay was performed by incubating 1-10% (v/v) crude protein extract containing GTF enzyme with 200 g/L sucrose in 25 mM or 50 mM sodium acetate buffer at pH 5.5 in the

presence or absence of 25 g/L dextran (MW ~1500, Sigma-Aldrich, Cat.#31394) at 37 °C and 125 rpm orbital shaking. One aliquot of reaction mixture was withdrawn at 1 h, 2 h and 3 h and heated at 90 °C for 5 min to inactivate the GTF. The insoluble material was removed by centrifugation at 13,000xg for 5 min, followed by filtration through 0.2 µm RC (regenerated cellulose) membrane. The resulting filtrate was analyzed by HPLC using two Aminex HPX-87C columns series at 85 °C (Bio-Rad, Hercules, CA) to quantify sucrose concentration. The sucrose concentration at each time point was plotted against the reaction time and the initial reaction rate was determined from the slope of the linear plot. One unit of GTF activity was defined as the amount of enzyme needed to consume one micromole of sucrose in one minute under the assay condition.

15 Determination of the α-Glucanohydrolase Activity

Insoluble mutan polymers required for determining mutanase activity were prepared using secreted enzymes produced by *Streptococcus sobrinus* ATCC® 33478™. Specifically, one loop of glycerol stock of *S. sobrinus* ATCC® 33478™ was streaked on a BHI agar plate (Brain Heart Infusion agar, Teknova, Hollister, CA), and the plate was incubated at 37 °C for 2 days; A few colonies were picked using a loop to inoculate 2X 100 mL BHI liquid medium in the original medium bottle from Teknova, and the culture was incubated at 37 °C, static for 24 h. The resulting cells were removed by centrifugation and the resulting supernatant was filtered through 0.2 µm sterile filter; 2X 101 mL of filtrate was collected. To the filtrate was added 2X 11.2 mL of 200 g/L sucrose (final sucrose 20 g/L). The reaction was incubated at 37 °C, with no agitation for 67 h. The resulting polysaccharide polymers were collected by centrifugation at 5000 xg for 10 min. The supernatant was carefully decanted. The insoluble polymers were washed 4 times with 40 mL of sterile water. The resulting mutan polymers were lyophilized for 48 h. Mutan polymer (390 mg) was suspended in 39 mL of sterile water to make suspension of 10 mg/mL. The mutan suspension was homogenized by

sonication (40% amplitude until large lumps disappear, ~ 10 min in total).
The homogenized suspension was aliquoted and stored at 4 °C.

A mutanase assay was initiated by incubating an appropriate amount of enzyme with 0.5 mg/mL mutan polymer (prepared as described above) in 25 mM KOAc buffer at pH 5.5 and 37 °C. At various time points, an aliquot of reaction mixture was withdrawn and quenched with equal volume of 100 mM glycine buffer (pH 10). The insoluble material in each quenched sample was removed by centrifugation at 14,000xg for 5 min. The reducing ends of oligosaccharide and polysaccharide polymer produced at each time point were quantified by the *p*-hydroxybenzoic acid hydrazide solution (PAHBAH) assay (Lever M., *Anal. Biochem.*, (1972) 47:273-279) and the initial rate was determined from the slope of the linear plot of the first three or four time points of the time course. The PAHBAH assay was performed by adding 10 µL of reaction sample supernatant to 100 µL of PAHBAH working solution and heated at 95 °C for 5 min. The working solution was prepared by mixing one part of reagent A (0.05 g/mL *p*-hydroxy benzoic acid hydrazide and 5% by volume of concentrated hydrochloric acid) and four parts of reagent B (0.05 g/mL NaOH, 0.2 g/mL sodium potassium tartrate). The absorption at 410 nm was recorded and the concentration of the reducing ends was calculated by subtracting appropriate background absorption and using a standard curve generated with various concentrations of glucose as standards.

Determination of Glycosidic Linkages

One-dimensional ¹H NMR data were acquired on a Varian Unity Inova system (Agilent Technologies, Santa Clara, CA) operating at 500 MHz using a high sensitivity cryoprobe. Water suppression was obtained by carefully placing the observe transmitter frequency on resonance for the residual water signal in a “presat” experiment, and then using the “tnnoesy” experiment with a full phase cycle (multiple of 32) and a mix time of 10 ms.

Typically, dried samples were taken up in 1.0 mL of D₂O and sonicated for 30 min. From the soluble portion of the sample, 100 µL was added to a 5 mm NMR tube along with 350 µL D₂O and 100 µL of D₂O

containing 15.3 mM DSS (4,4-dimethyl-4-silapentane-1-sulfonic acid sodium salt) as internal reference and 0.29% NaN₃ as bactericide. The abundance of each type of anomeric linkage was measured by the integrating the peak area at the corresponding chemical shift. The percentage of each type of anomeric linkage was calculated from the abundance of the particular linkage and the total abundance anomeric linkages from oligosaccharides.

Methylation Analysis

The distribution of glucosidic linkages in glucans was determined by a well-known technique generally named "methylation analysis," or "partial methylation analysis" (see: F. A. Pettolino, *et al.*, *Nature Protocols*, (2012) 7(9):1590-1607). The technique has a number of minor variations but always includes: 1. methylation of all free hydroxyl groups of the glucose units, 2. hydrolysis of the methylated glucan to individual monomer units, 3. reductive ring-opening to eliminate anomers and create methylated glucitols; the anomeric carbon is typically tagged with a deuterium atom to create distinctive mass spectra, 4. acetylation of the free hydroxyl groups (created by hydrolysis and ring opening) to create partially methylated glucitol acetates, also known as partially methylated products, 5. analysis of the resulting partially methylated products by gas chromatography coupled to mass spectrometry and/or flame ionization detection.

The partially methylated products include non-reducing terminal glucose units, linked units and branching points. The individual products are identified by retention time and mass spectrometry. The distribution of the partially-methylated products is the percentage (area %) of each product in the total peak area of all partially methylated products. The gas chromatographic conditions were as follows: RTX-225 column (30 m x 250 µm ID x 0.1 µm film thickness, Restek Corporation, Bellefonte, PA, USA), helium carrier gas (0.9 mL/min constant flow rate), oven temperature program starting at 80°C (hold for 2 min) then 30°C/min to 170°C (hold for 0 min) then 4°C/min to 240°C (hold for 25 min), 1 µL injection volume (split 5:1), detection using electron impact mass spectrometry (full scan mode)

Viscosity Measurement

The viscosity of 12 wt% aqueous solutions of soluble oligomer/polymer was measured using a TA Instruments AR-G2 controlled-stress rotational rheometer (TA Instruments – Waters, LLC, New Castle, DE) equipped with a cone and plate geometry. The geometry consists of a 40 mm 2° upper cone and a peltier lower plate, both with smooth surfaces. An environmental chamber equipped with a water-saturated sponge was used to minimize solvent (water) evaporation during the test. The viscosity was measured at 20 °C. The peltier was set to the desired temperature and 0.65 mL of sample was loaded onto the plate using an Eppendorf pipette (Eppendorf North America, Hauppauge, NY). The cone was lowered to a gap of 50 µm between the bottom of the cone and the plate. The sample was thermally equilibrated for 3 minutes. A shear rate sweep was performed over a shear rate range of 500-10 s⁻¹. Sample stability was confirmed by running repeat shear rate points at the end of the test.

Determination of the Concentration of Sucrose, Glucose, Fructose and Leucrose

Sucrose, glucose, fructose, and leucrose were quantitated by HPLC with two tandem Aminex HPX-87C Columns (Bio-Rad, Hercules, CA). Chromatographic conditions used were 85 °C at column and detector compartments, 40 °C at sample and injector compartment, flow rate of 0.6 mL/min, and injection volume of 10 µL. Software packages used for data reduction were EMPOWER™ version 3 from Waters (Waters Corp., Milford, MA). Calibrations were performed with various concentrations of standards for each individual sugar.

Determination of the Concentration of Oligosaccharides

Soluble oligosaccharides were quantitated by HPLC with two tandem Aminex HPX-42A columns (Bio-Rad). Chromatographic conditions used were 85 °C column temperature and 40 °C detector temperature, water as mobile phase (flow rate of 0.6 mL/min), and injection volume of 10 µL. Software package used for data reduction was EMPOWER™

version 3 from Waters Corp. Oligosaccharide samples from DP2 to DP7 were obtained from Sigma-Aldrich: maltoheptaose (DP7, Cat.# 47872), maltohexanose (DP6, Cat.# 47873), maltopentose (DP5, Cat.# 47876), maltotetraose (DP4, Cat.# 47877), isomaltotriose (DP3, Cat.# 47884) and maltose (DP2, Cat.#47288). Calibration was performed for each individual oligosaccharide with various concentrations of the standard.

Purification of Soluble Oligosaccharide Oligomer/Polymer

Soluble oligosaccharide oligomer/polymer present in product mixtures produced by the conversion of sucrose using glucosyltransferase enzymes with or without added mutanases as described in the following examples were purified and isolated by size-exclusion column chromatography (SEC). In a typical procedure, product mixtures were heat-treated at 60 °C to 90 °C for between 15 min and 30 min and then centrifuged at 4000 rpm for 10 min. The resulting supernatant was injected onto an ÄKTAprime purification system (SEC; GE Healthcare Life Sciences) (10 mL – 50 mL injection volume) connected to a GE HK 50/60 column packed with 1.1L of Bio-Gel P2 Gel (Bio-Rad, Fine 45-90 µm) using water as eluent at 0.7 mL/min. The SEC fractions (~5 mL per tube) were analyzed by HPLC for oligosaccharides using a Bio-Rad HPX-47A column. Fractions containing >DP2 oligosaccharides were combined and the soluble oligomer/polymer isolated by rotary evaporation of the combined fractions to produce a solution containing between 3 % and 6 % (w/w) solids, where the resulting solution was lyophilized to produce the soluble oligomer/polymer as a solid product.

EXAMPLE 1

PRODUCTION OF MUTANASE MUT3264 GI: 257153264 in *E. coli* BL21(DE3)

A gene encoding mutanase from *Paenibacillus Humicus* NA1123 identified in GENBANK® as GI:257153264 (SEQ ID NO: 1) was synthesized by GenScript (GenScript USA Inc., Piscataway, NJ). The nucleotide sequence (SEQ ID NO: 2) encoding protein sequence ("mut3264"; SEQ ID NO: 3) was subcloned into pET24a (Novagen; Merck KGaA, Darmstadt, Germany). The resulting plasmid was transformed into

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GenScript and cloned into the NheI and HindIII sites of the replicative *Bacillus* expression pHYT vector under the *aprE* promoter and fused with the *B. subtilis* AprE signal peptide (SEQ ID NO: 4) on the vector. The construct was first transformed into *E. coli* DH10B and selected on LB with ampicillin (100 µg/mL) plates. The confirmed construct pDCQ921 was then transformed into *B. subtilis* BG6006 and selected on the LB plates with tetracycline (12.5 µg/mL). The resulting *B. subtilis* expression strain SG1021 was purified and a single colony isolate, SG1021-1, was used as the source of the mutanase mut3264. SG1021-1 strain was first grown in LB containing 10 µg/mL tetracycline, and then sub-cultured into GrantsII medium containing 12.5 µg/mL tetracycline and grown at 37 °C for 2-3 days. The cultures were spun at 15,000 xg for 30 min at 4 °C and the supernatant filtered through a 0.22 µm filter. The filtered supernatant containing mut3264 was aliquoted and frozen at -80°C.

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EXAMPLE 3

PRODUCTION OF MUTANASE MUT3325 GI: 212533325

A gene encoding the *Penicillium marneffe* ATCC® 18224™ mutanase identified in GENBANK® as gi:212533325 was synthesized by GenScript (Piscataway, NJ). The nucleotide sequence (SEQ ID NO: 7) encoding protein sequence (mut3325; SEQ ID NO: 8) was subcloned into plasmid pTrex3 (SEQ ID NO: 9) at SacII and Ascl restriction sites, a vector designed to express the gene of interest in *Trichoderma reesei*, under control of *CBHI* promoter and terminator, with *Aspergillus niger* acetamidase for selection. The resulting plasmid was transformed into *T. reesei* by biolistic injection as described in the general method section, above. The detailed method of biolistic transformation is described in International PCT Patent Application Publication WO2009/126773 A1. A 1 cm² agar plug with spores from a stable clone TRM05-3 was used to inoculate the production media (described below). The culture was grown in the shake flasks for 4-5 days at 28 °C and 220 rpm. To harvest the secreted proteins, the cell mass was first removed by centrifugation at 4000 xg for 10 min and the supernatant was filtered through 0.2 µM sterile filters. The expression of mutanase mut3325 was confirmed by SDS-PAGE.

The production media component is listed below.

NREL-Trich Lactose Defined

| Formula | Amount | Units |
|--|--------|-------|
| ammonium sulfate | 5 | g |
| PIPPS | 33 | g |
| BD Bacto casamino acid | 9 | g |
| KH ₂ PO ₄ | 4.5 | g |
| CaCl ₂ .2H ₂ O | 1.32 | g |
| MgSO ₄ .7H ₂ O | 1 | g |
| <i>T. reesei</i> trace elements | 2.5 | mL |
| NaOH pellet | 4.25 | g |
| Adjust pH to 5.5 with 50% NaOH | | |
| Bring volume to | 920 | mL |
| Add to each aliquot: Foamblast | 5 | Drops |
| Autoclave, then add 20 % lactose filter sterilized | 80 | mL |

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T. reesei trace elements

| Formula | Amount | Units |
|---|--------|-------|
| citric acid.H ₂ O | 191.41 | g |
| FeSO ₄ .7H ₂ O | 200 | g |
| ZnSO ₄ .7H ₂ O | 16 | g |
| CuSO ₄ .5H ₂ O | 3.2 | g |
| MnSO ₄ .H ₂ O | 1.4 | g |
| H ₃ BO ₃ (boric acid) | 0.8 | g |
| Bring volume to | 1 | L |

EXAMPLE 4

PRODUCTION OF MUT3325 BY FERMENTATION

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Fermentation seed culture was prepared by inoculating 0.5 L of minimal medium in a 2-L baffled flask with 1.0 mL frozen spore suspension of the mut3325 expression strain TRM05-3 (Example 3) (The minimal medium was composed of 5 g/L ammonium sulfate, 4.5 g/L potassium phosphate monobasic, 1.0 g/L magnesium sulfate heptahydrate, 14.4 g/L citric acid anhydrous, 1 g/L calcium chloride dihydrate, 25 g/L glucose and trace elements including 0.4375 g/L citric acid, 0.5 g/L ferrous sulfate heptahydrate, 0.04 g/L zinc sulfate heptahydrate, 0.008 g/L cupric sulfate pentahydrate, 0.0035 g/L manganese sulfate monohydrate and 0.002 g/L boric acid. The pH was 5.5.). The culture was grown at 32 °C and 170 rpm for 48 hours before transferred to 8 L of the production medium in a 14-L fermentor. The production medium was composed of 75 g/L glucose, 4.5 g/L potassium phosphate monobasic, 0.6 g/L calcium chloride dehydrate, 1.0 g/L magnesium sulfate heptahydrate, 7.0 g/L ammonium sulfate, 0.5 g/L citric acid anhydrous, 0.5 g/L ferrous sulfate heptahydrate, 0.04 g/L zinc sulfate heptahydrate, 0.00175 g/L cupric sulfate pentahydrate, 0.0035g/L manganese sulfate monohydrate, 0.002 g/L boric acid and 0.3 mL/L foam blast 882.

The fermentation was first run with batch growth on glucose at 34 °C, 500 rpm for 24 h. At the end of 24 h, the temperature was lowered to 28 °C and agitation speed was increased to 1000 rpm. The fermentor was then fed with a mixture of glucose and sophorose (62% w/w) at specific feed rate of 0.030 g glucose-sophorose solids / g biomass / hr. At the end of run, the biomass was removed by centrifugation and the supernatant containing the mutanase was concentrated about 10-fold by ultrafiltration using 10-kD Molecular Weight Cut-Off ultrafiltration cartridge (UFP-10-E-35; GEHealthcare, Little Chalfont, Buckinghamshire, UK). The concentrated protein was stored at -80 °C.

EXAMPLE 5

PRODUCTION OF GTF GI: 51574154 IN *E. coli* TOP10

A gene encoding a truncated version of the gtf enzyme from *Lactobacillus reuteri* identified in GENBANK® as gi:51574154 (SEQ ID NO: 10) was synthesized using codons optimized for expression in *E. coli* (DNA 2.0, Menlo Park CA). The nucleic acid product (SEQ ID NO: 11), encoding protein 4154 (SEQ ID NO: 12), was subcloned into PJEXPRESS404® (DNA 2.0, Menlo Park CA) to generate the plasmid identified as pMP80. The plasmid pMP80 was used to transform *E. coli* TOP10 (Invitrogen, Carlsbad California) to generate the strain identified as TOP10/pMP80.

E. coli strain TOP10/pMP80 expressing the GTF enzyme "4154" was grown in LB medium with ampicillin (100 µg/mL) at 37 °C with shaking to OD600nm = 0.4 - 0.5, at which time IPTG was added to a final concentration of 0.5 mM, and incubation continued for 2-4 hours at 37 °C. Cells were harvested by centrifugation at 5,000 xg for 15 minutes and resuspended (20% w/v) in 50 mM phosphate buffer pH 7.0 supplemented with DTT (1.0 mM). Resuspended cells were passed through a French Pressure Cell (SLM Instruments, Rochester, NY) twice to ensure >95% cell lysis. Lysed cells were centrifuged for 30 minutes at 12,000 xg at 4 °C. The resulting supernatant was analyzed by the BCA protein assay and SDS-PAGE to confirm expression of the gtf enzyme, and the supernatant was stored at -20 °C.

GTF activity was confirmed by measuring the production of reducing sugars (fructose and glucose) in a gtf reaction solution in which extract was added (5% by volume) to a mixture containing sucrose (50 mg/mL), dextran T-10 (1 mg/mL) and potassium phosphate buffer (pH 6.5, 50 mM) at 22- 25 °C for 24-30 hours. Reducing sugars were subsequently measured by adding 0.01 mL of a centrifuged GTF reaction solution to a mixture containing 1 N NaOH and 0.1% triphenyltetrazolium chloride and monitoring the increase in absorbance at OD480nm for 5 minutes (Ultrospec, Pharmacia LKB, New York, NY).

EXAMPLE 6

ISOLATION OF SOLUBLE OLIGOSACCHARIDE FIBER PRODUCED BY
THE COMBINATION OF GTF4154 AND MUT3264

A 1000 mL reaction containing 100 g/L sucrose, *E. coli* crude protein extract (1.0% v/v) containing GTF enzyme from *Lactobacillus reuteri* identified in GENBANK® as gi:51574154 (Example 5), and *E. coli* crude protein extract (1.0% v/v) comprising a mutanase from *Paenibacillus humicus* (mut3264, gi:257153264; Example 1) in 10 mM potassium phosphate buffer (pH 6.0) was stirred at 37 °C for 30 h, then heated to 90 °C for 15 min to inactivate the enzymes. The resulting product mixture was centrifuged and the resulting supernatant analyzed by HPLC for soluble monosaccharides, disaccharides and oligosaccharides, then 132 mL of the supernatant was purified by SEC using BioGel P2 resin (BioRad). The SEC fractions that contained oligosaccharides \geq DP3 were combined and concentrated by rotary evaporation for analysis by HPLC (Table 1).

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Table 1. Soluble oligosaccharide oligomer/polymer produced by GTF4154/mut3264 mutanase.

| 100 g/L sucrose, GTF Gl: 51574154, mut3264, 37 °C, 30h | | |
|--|----------------------|---------------------------|
| | Product mixture, g/L | SEC-purified product, g/L |
| ≥DP8 | 23.9 | 74.4 |
| DP7 | 2.6 | 6.1 |
| DP6 | 2.5 | 4.9 |
| DP5 | 2.3 | 4.1 |
| DP4 | 1.3 | 1.8 |
| DP3 | 1.3 | 1.1 |
| DP2 | 2.5 | 0.6 |
| Sucrose | 0.0 | 0.2 |
| Leucrose | 7.4 | 0.3 |
| Glucose | 3.7 | 0.1 |
| Fructose | 44.1 | 0.1 |
| Sum DP2-≥DP8 | 33.9 | 93.0 |
| Sum DP3-≥DP8 | 36.4 | 92.4 |

EXAMPLE 7

5 ISOLATION OF SOLUBLE OLIGOSACCHARIDE FIBER PRODUCED BY THE COMBINATION OF GTF4154 AND DEXTRANASE

A 1200 mL reaction containing 100 g/L sucrose, *E. coli* crude protein extract (1.0% v/v) containing GTF enzyme from *Lactobacillus reuteri* identified in GENBANK® as gi:51574154 (Example 5), and 0.01 %
 10 (v/v) dextranase (1,6- α -D-Glucan 6-glucanhydrolase from *Chaetomium erraticum*, Sigma catalog D-0443) in 10 mM potassium phosphate buffer (pH 6.5), was stirred at 37 °C for 45 h, then heated to 90 °C for 15 min to inactivate the enzymes. The resulting product mixture was centrifuged and the resulting supernatant analyzed by HPLC for soluble monosaccharides,
 15 disaccharides and oligosaccharides, then the supernatant was purified by SEC using BioGel P2 resin (BioRad). The SEC fractions that contained

oligosaccharides \geq DP3 were combined and concentrated by rotary evaporation for analysis by HPLC (Table 2).

Table 2. Soluble oligosaccharide oligomer/polymer produced by GTF4154 and dextranase.

| 100 g/L sucrose, GTF GI: 51574154, dextranase, 37 °C, 45h | | |
|--|----------------------------|---------------------------------|
| | Product mixture, g/L | SEC-purified product, g/L |
| \geq DP8 | 22.6 | 64.2 |
| DP7 | 3.3 | 5.8 |
| DP6 | 3.5 | 5.0 |
| DP5 | 3.6 | 4.4 |
| DP4 | 1.8 | 1.7 |
| DP3 | 1.5 | 1.1 |
| DP2 | 4.0 | 1.1 |
| Sucrose | 0 | 0.7 |
| Leucrose | 7.4 | 0.6 |
| Glucose | 3.6 | 0.5 |
| Fructose | 46.3 | 2.3 |
| Sum DP2- \geq DP8 | 40.3 | 83.3 |
| Sum DP3- \geq DP8 | 36.3 | 82.2 |

EXAMPLE 8

ANOMERIC LINKAGE ANALYSIS OF SOLUBLE FIBER PRODUCED BY COMBINATION OF GTF4154 AND MUT3264 OR DEXTRANASE

10 Solutions of chromatographically-purified soluble oligosaccharide oligomer/polymers prepared as described in Examples 6 and Example 7 were dried to a constant weight by lyophilization, and the resulting solids analyzed by ^1H NMR spectroscopy and by GC/MS as described in the General Methods section (above). The anomeric linkages for each of
15 these soluble oligosaccharide oligomer/polymer mixtures are reported in Tables 3 and 4.

Table 3. Anomeric linkage analysis of soluble oligomer/polymer by ^1H NMR spectroscopy.

| Example # | GTF | % α - (1,3) | % α - (1,2) | % α - (1,3,6) | % α - (1,2,6) | % α -(1,6) |
|-----------|--------------------|--------------------------|--------------------------|----------------------------|----------------------------|----------------------|
| 6 | GTF4154/mut3264 | 0 | 0.0 | 29.5 | 0 | 70.5 |
| 7 | GTF4154/dextranase | 0 | 0.0 | 32.5 | 0 | 67.5 |

Table 4. Anomeric linkage analysis of soluble oligomer/polymer by GC/MS.

| Example # | GTF | % α -(1,4) | % α -(1,3) | % α -(1,3,6) | % 2,1 Fruc | % α -(1,2) | % α -(1,6) | % α -(1,3,4) | % α -(1,2,3) | % α -(1,4,6) + α -(1,2,6) |
|-----------|--------------------|----------------------|----------------------|------------------------|---------------|----------------------|----------------------|------------------------|------------------------|--|
| 6 | GTF4154/mut3264 | 1.3 | 27.6 | 9.5 | 0.2 | 0.5 | 60.3 | 0.0 | 0.0 | 0.6 |
| 7 | GTF4154/dextranase | 1.4 | 29.0 | 9.3 | 0.2 | 0.5 | 59.1 | 0.0 | 0.0 | 0.6 |

EXAMPLE 9VISCOSITY OF SOLUBLE FIBER PRODUCED BY COMBINATION OF
GTF4154 AND MUT3264 OR DEXTRANASE

5 Solutions of chromatographically-purified soluble oligosaccharide oligomer/polymers prepared as described in Examples 6 and Example 7 were dried to a constant weight by lyophilization, and the resulting solids were used to prepare a 12 wt% solution of soluble oligomer/polymer in distilled, deionized water. The viscosity of the soluble oligomer/polymer solutions (reported in centipoise (cP), where 1 cP = 1 millipascal-s (mPa-s)) (Table 5) was measured at 20 °C as described in the General Methods section.

15 Table 5. Viscosity of 12 % (w/w) soluble oligomer/polymer solutions measured at 20 °C (ND = not determined).

| Example # | GTF | viscosity (cP) |
|-----------|--------------------|----------------|
| 6 | GTF4154/mut3264 | 9.8 |
| 7 | GTF4154/dextranase | 5.1 |

EXAMPLE 10MOLECULAR WEIGHT OF FIBER PRODUCED BY COMBINATION OF
GTF4154 AND MUT3264 OR DEXTRANASE

20 A solution of chromatographically-purified soluble oligosaccharide oligomer/polymers prepared as described in Examples 6 and Example 7 were dried to a constant weight by lyophilization, and the resulting solids were analyzed by SEC chromatography for number average molecular weight (M_n), weight average molecular weight (M_w), peak molecular weight (M_p), z-average molecular weight (M_z), and polydispersity index (PDI = M_w/M_n) as described in the General Methods section (Table 6).

Table 6. Characterization of soluble oligomer/polymer by SEC.

| Example # | GTF or GTF/mutanase | Component (%) | M _n (Daltons) | M _w (Daltons) | M _p (Daltons) | M _z (Daltons) | PDI |
|-----------|---------------------|---------------|--------------------------|--------------------------|--------------------------|--------------------------|------|
| 6 | GTF4154/mut3264 | 69 | 1663 | 2058 | 2015 | 2460 | 1.24 |
| 6 | GTF4154/mut3264 | 31 | 529436 | 784727 | 808747 | 949419 | 1.48 |
| 7 | GTF4154/dextranase | 66 | 1596 | 1984 | 1926 | 2407 | 1.24 |
| 7 | GTF4154/dextranase | 22 | 458381 | 612419 | 651301 | 763911 | 1.34 |

EXAMPLE 11PRODUCTION OF GTF GI: 51574154 IN *BACILLUS SUBTILIS*

The nucleic acid product (SEQ ID NO: 11) encoding protein GTF4154 was amplified from the *E. coli* expression plasmid pMP80 with flanking NheI and HindIII restriction sites and cloned into the NheI and HindIII sites of the *Bacillus subtilis* integrative expression plasmid p4JH under the *aprE* promoter and fused with the *B. subtilis* AprE signal peptide (SEQ ID NO: 4) on the vector. The construct was first transformed into *E. coli* DH10B and selected on LB with ampicillin (100 ug/mL) plates. The confirmed construct pDCQ985 expressing GTF4154 was then transformed into *B. subtilis* BG6006 contains 9 protease deletions (*amyE::xylRPxylAcomK-ermC*, *degUHy32*, *oppA*, $\Delta spoIIE3501$, $\Delta aprE$, $\Delta nprE$, $\Delta depr$, $\Delta ispA$, Δbpr , Δvpr , $\Delta wprA$, $\Delta mpr-ybfJ$, $\Delta nprB$) and selected on the LB plates with chloramphenicol (5 ug/ml). The colonies grown on LB plates with 5 ug/mL chloramphenicol were streaked several times onto LB plates with 25 ug/mL chloramphenicol. The resulted *B. subtilis* expression strain SG1185 was grown in LB medium with 25 ug/mL chloramphenicol first and then subcultured into GrantsII medium containing 25 ug/mL chloramphenicol grown at 30 °C for 2-3 days. The cultures were spun at 15,000 xg for 30 min at 4 °C and the supernatant was filtered through 0.22 um filters. The filtered supernatant was aliquoted and frozen at -80 °C.

EXAMPLE 12Preparation of a Sodium Carboxymethyl α -Glucan

This Example describes producing the glucan ether derivative, carboxymethyl glucan, using the α -glucan oligomer/polymer composition described herein.

Approximately 1 g of an α -glucan oligomer/polymer composition as described in Examples 6 or 7 is added to 20 mL of isopropanol in a 50-mL capacity round bottom flask fitted with a thermocouple for temperature monitoring and a condenser connected to a recirculating bath, and a magnetic stir bar. Sodium hydroxide (4 mL of a 15% solution) is added drop wise to the preparation, which is then heated to 25 °C on a hotplate.

The preparation is stirred for 1 hour before the temperature is increased to 55 °C. Sodium monochloroacetate (0.3 g) is then added to provide a reaction, which is held at 55 °C for 3 hours before being neutralized with glacial acetic acid. The material is then collected and analyzed by NMR to determine degree of substitution (DoS) of the solid.

Various DoS samples of carboxymethyl α -glucan are prepared using processes similar to the above process, but with certain modifications such as the use of different reagent (sodium monochloroacetate): α -glucan oligomer/polymer molar ratios, different NaOH: α -glucan oligomer/polymer molar ratios, different temperatures, and/or reaction times.

EXAMPLE 13

Viscosity Modification Using Carboxymethyl α -Glucan

This Example describes the effect of carboxymethyl α -glucan on the viscosity of an aqueous composition.

Various sodium carboxymethyl glucan samples as prepared in Example 12 are tested. To prepare 0.6 wt% solutions of each of these samples, 0.102 g of sodium carboxymethyl α -glucan is added to DI water (17 g). Each preparation is then mixed using a bench top vortexer at 1000 rpm until completely dissolved.

To determine the viscosity of carboxymethyl α -glucan, each solution of the dissolved α -glucan ether samples is subjected to various shear rates using a Brookfield III+ viscometer equipped with a recirculating bath to control temperature (20 °C). The shear rate is increased using a gradient program which increased from 0.1-232.5 rpm and the shear rate is increased by 4.55 (1/s) every 20 seconds.

EXAMPLE 14

Preparation of Carboxymethyl Dextran from Solid Dextran

This Example describes producing carboxymethyl dextran for use in Example 15.

Approximately 0.5 g of solid dextran ($M_w = 750000$) was added to 10 mL of isopropanol in a 50-mL capacity round bottom flask fitted with a thermocouple for temperature monitoring and a condenser connected to a recirculating bath, and a magnetic stir bar. Sodium hydroxide (0.9 mL of a

15% solution) was added drop wise to the preparation, which was then heated to 25 °C on a hotplate. The preparation was stirred for 1 hour before the temperature was increased to 55 °C. Sodium monochloroacetate (0.15 g) was then added to provide a reaction, which was held at 55 °C for 3 hours before being neutralized with glacial acetic acid. The solid material was then collected by vacuum filtration and washed with ethanol (70%) four times, dried under vacuum at 20-25 °C, and analyzed by NMR to determine degree of substitution (DoS) of the solid. The solid was identified as sodium carboxymethyl dextran.

Additional sodium carboxymethyl dextran was prepared using dextran of different M_w . The DoS values of carboxymethyl dextran samples prepared in this example are provided in Table 7.

Table 7

Samples of Sodium Carboxymethyl Dextran Prepared from Solid Dextran

| Product Sample Designation | Dextran M_w | Reagent ^a :Dextran Molar Ratio ^b | NaOH:Dextran Molar Ratio ^b | Reaction Time (hours) | DoS |
|----------------------------|---------------|--|---------------------------------------|-----------------------|------|
| 2A | 750000 | 0.41 | 1.08 | 3 | 0.64 |
| 2B | 1750000 | 0.41 | 0.41 | 3 | 0.49 |

^a Reagent refers to sodium monochloroacetate.

^b Molar ratios calculated as moles of reagent per moles of dextran (third column), or moles of NaOH per moles of dextran (fourth column).

These carboxymethyl dextran samples were tested for their viscosity modification effects in Example 15.

EXAMPLE 15 (Comparative)

Effect of Shear Rate on Viscosity of Carboxymethyl Dextran

This Example describes the viscosity, and the effect of shear rate on viscosity, of solutions containing the carboxymethyl dextran samples prepared in Example 14.

Various sodium carboxymethyl dextran samples (2A and 2B) were prepared as described in Example 14. To prepare 0.6 wt% solutions of each of these samples, 0.102 g of sodium carboxymethyl dextran was added to DI water (17 g). Each preparation was then mixed using a bench top vortexer at 1000 rpm until the solid was completely dissolved.

To determine the viscosity of carboxymethyl dextran at various shear rates, each solution of the dissolved dextran ether samples was subjected to various shear rates using a Brookfield III+ viscometer equipped with a recirculating bath to control temperature (20 °C). The shear rate was increased using a gradient program which increased from 0.1-232.5 rpm and the shear rate was increased by 4.55 (1/s) every 20 seconds. The results of this experiment at 14.72 (1/s) are listed in Table y+1.

Table 8

Viscosity of Carboxymethyl Dextran Solutions at Various Shear Rates

| Sample | Sample Loading (wt%) | Viscosity (cPs) @ 66.18 rpm | Viscosity (cPs) @ 110.3 rpm | Viscosity (cPs) @ 183.8 rpm | Viscosity (cPs) @ 250 rpm |
|--------|----------------------|-----------------------------|-----------------------------|-----------------------------|---------------------------|
| 2A | 0.6 | 4.97 | 2.55 | 4.43 | 3.88 |
| 2B | 0.6 | 6.86 | 5.68 | 5.28 | 5.26 |

The results summarized in Table 8 indicate that 0.6 wt% solutions of carboxymethyl dextran have viscosities of about 2.5-7 cPs.

EXAMPLE 16 (Comparative)

Preparation of Carboxymethyl α -Glucan

This Example describes producing carboxymethyl glucan for use in Example 17.

The glucan was prepared as described in Examples 6 or 7.

Approximately 150 g of the α -glucan oligomer/polymer composition is added to 3000 mL of isopropanol in a 500-mL capacity round bottom flask fitted with a thermocouple for temperature monitoring and a condenser connected to a recirculating bath, and a magnetic stir bar. Sodium hydroxide (600 mL of a 15% solution) is added drop wise to the preparation, which is then heated to 25 °C on a hotplate. The preparation is stirred for 1 hour before the temperature is increased to 55 °C. Sodium monochloroacetate is then added to provide a reaction, which is held at 55 °C for 3 hours before being neutralized with 90% acetic acid. The material is then collected and analyzed by NMR to determine degree of substitution (DoS).

Various DoS samples of carboxymethyl α -glucan are prepared using processes similar to the above process, but with certain modifications such as the use of different reagent (sodium monochloroacetate): α -glucan oligomer/polymer molar ratios, different NaOH: α -glucan oligomer/polymer molar ratios, different temperatures, and/or reaction times.

EXAMPLE 17 (Comparative)

Viscosity Modification Using Carboxymethyl α -Glucan

This Example describes the effect of carboxymethyl α -glucan on the viscosity of an aqueous composition.

Various sodium carboxymethyl glucan samples are prepared as described in Example 16. To prepare 0.6 wt% solutions of each of these samples, 0.102 g of sodium carboxymethyl α -glucan is added to DI water (17 g). Each preparation is then mixed using a bench top vortexer at 1000 rpm until completely dissolved.

To determine the viscosity of carboxymethyl glucan at various shear rates, each solution of the glucan ether samples is subjected to various shear rates using a Brookfield III+ viscometer equipped with a recirculating bath to control temperature (20 °C). The shear rate is increased using a gradient program which increased from 0.1-232.5 rpm and then the shear rate is increased by 4.55 (1/s) every 20 seconds.

EXAMPLE 18 (Comparative)

Viscosity Modification Using Carboxymethyl Cellulose

This Example describes the effect of carboxymethyl cellulose (CMC) on the viscosity of an aqueous composition.

CMC samples obtained from DuPont Nutrition & Health (Danisco) were dissolved in DI water to prepare 0.6 wt% solutions of each sample.

To determine the viscosity of CMC at various shear rates, each solution of the dissolved CMC samples was subjected to various shear rates using a Brookfield III+ viscometer equipped with a recirculating bath to control temperature (20 °C). The shear rate was increased using a gradient program which increased from 0.1-232.5 rpm and the shear rate was increased by 4.55 (1/s) every 20 seconds. Results of this experiment at 14.72 (1/s) are listed in Table 9.

Table 9Viscosity of CMC Solutions

| Sample | Molecular Weight (Mw) | DoS | Sample Loading (wt%) | Viscosity (cPs) @ 14.9 rpm |
|---------------|-----------------------|-------|----------------------|----------------------------|
| C3A (BAK 130) | ~130000 | 0.66 | 0.6 | 235.03 |
| C3B (BAK 550) | ~550000 | 0.734 | 0.6 | 804.31 |

CMC (0.6 wt%) therefore can increase the viscosity of an aqueous solution.

EXAMPLE 19

Creating Calibration Curves for Direct Red 80 and Toluidine Blue O Dyes
Using UV Absorption

This example discloses creating calibration curves that could be useful for determining the relative level of adsorption of glucan ether derivatives onto fabric surfaces.

Solutions of known concentration (ppm) are made using Direct Red 80 and Toluidine Blue O dyes. The absorbance of these solutions are measured using a LAMOTTE SMART2 Colorimeter at either 520 nm (Direct Red 80) or 620 nm (Toluidine Blue O Dye). The absorption information is plotted in order that it can be used to determine dye concentration of solutions exposed to fabric samples. The concentration and absorbance of each calibration curve are provided in Tables 10 and 11.

Table 10Direct Red 80 Dye Calibration Curve Data

| Dye Concentration (ppm) | Average Absorbance @520 nm |
|--------------------------------|-----------------------------------|
| 25 | 0.823333333 |
| 22.5 | 0.796666667 |
| 20 | 0.666666667 |
| 15 | 0.51 |
| 10 | 0.37 |
| 5 | 0.2 |

Table 11Toluidine Blue O Dye Calibration Curve Data

| Dye Concentration (ppm) | Average Absorbance @620 nm |
|--------------------------------|-----------------------------------|
| 12.5 | 1.41 |
| 10 | 1.226666667 |
| 7 | 0.88 |
| 5 | 0.676666667 |
| 3 | 0.44 |
| 1 | 0.166666667 |

Thus, calibration curves were prepared that are useful for determining the relative level of adsorption of poly alpha-1,3-glucan ether derivatives onto fabric surfaces.

EXAMPLE 20Preparation of Quaternary Ammonium Glucan

This Example describes how one could produce a quaternary ammonium glucan ether derivative. Specifically, trimethylammonium hydroxypropyl glucan can be produced.

Approximately 10 g of the α -glucan oligomer/polymer composition (prepared as in Examples 6 or 7) is added to 100 mL of isopropanol in a 500-mL capacity round bottom flask fitted with a thermocouple for temperature monitoring and a condenser connected to a recirculating bath, and a magnetic stir bar. 30 mL of sodium hydroxide (17.5% solution) is added drop wise to this preparation, which is then heated to 25 °C on a hotplate. The preparation is stirred for 1 hour before the temperature is increased to 55 °C. 3-chloro-2-hydroxypropyl-trimethylammonium chloride (31.25 g) is then added to provide a reaction, which is held at 55 °C for 1.5 hours before being neutralized with 90% acetic acid. The product that forms (trimethylammonium hydroxypropyl glucan) is collected by vacuum filtration and washed with ethanol (95%) four times, dried under vacuum at 20-25 °C, and analyzed by NMR and SEC to determine molecular weight and DoS.

Thus, the quaternary ammonium glucan ether derivative, trimethylammonium hydroxypropyl glucan, can be prepared and isolated.

EXAMPLE 21

Effect of Shear Rate on Viscosity of Quaternary Ammonium Glucan

This Example describes how one could test the effect of shear rate on the viscosity of trimethylammonium hydroxypropyl glucan as prepared in Example 22. It is contemplated that this glucan ether derivative exhibits shear thinning or shear thickening behavior.

Samples of trimethylammonium hydroxypropyl glucan are prepared as described in Example 20. To prepare a 2 wt% solution of each sample, 1 g of sample is added to 49 g of DI water. Each preparation is then homogenized for 12-15 seconds at 20,000 rpm to dissolve the trimethylammonium hydroxypropyl glucan sample in the water.

To determine the viscosity of each 2 wt% quaternary ammonium glucan solution at various shear rates, each solution is subjected to various shear rates using a Brookfield DV III+ Rheometer equipped with a recirculating bath to control temperature (20 °C) and a ULA (ultra low adapter) spindle and adapter set. The shear rate is increased using a gradient program which increases from 10-250 rpm and the shear rate is increased by 4.9 1/s every 20 seconds for the ULA spindle and adapter.

It is contemplated that the viscosity of each of the quaternary ammonium glucan solutions would change (reduced or increased) as the shear rate is increased, thereby indicating that the solutions demonstrate shear thinning or shear thickening behavior. Such would indicate that quaternary ammonium glucan could be added to an aqueous liquid to modify its rheological profile.

EXAMPLE 22

Adsorption of Quaternary Ammonium Glucan on Various Fabrics

This example discloses how one could test the degree of adsorption of a quaternary ammonium glucan (trimethylammonium hydroxypropyl glucan) on different types of fabrics.

A 0.07 wt% solution of trimethylammonium hydroxypropyl glucan (as prepared in Example 20) is made by dissolving 0.105 g of the polymer in 149.89 g of deionized water. This solution is divided into several aliquots with different concentrations of polymer (Table 12). Other

components are added such as acid (dilute hydrochloric acid) or base (sodium hydroxide) to modify pH, or NaCl salt.

Table 12
Quaternary Ammonium Glucan Solutions Useful in Fabric Adsorption
Studies

| Amount of NaCl (g) | Amount of Solution (g) | Polymer Concentration (wt%) | Final pH |
|--------------------|------------------------|-----------------------------|----------|
| 0 | 15 | 0.07 | ~7 |
| 0.15 | 14.85 | 0.0693 | ~7 |
| 0.3 | 14.7 | 0.0686 | ~7 |
| 0.45 | 14.55 | 0.0679 | ~7 |
| 0 | 9.7713 | 0.0683 | ~3 |
| 0 | 9.7724 | 0.0684 | ~5 |
| 0 | 10.0311 | 0.0702 | ~9 |
| 0 | 9.9057 | 0.0693 | ~11 |

Four different fabric types (cretonne, polyester, 65:35 polyester/cretonne, bleached cotton) are cut into 0.17 g pieces. Each piece is placed in a 2-mL well in a 48-well cell culture plate. Each fabric sample is exposed to 1 mL of each of the above solutions (Table 12) for a total of 36 samples (a control solution with no polymer is included for each fabric test). The fabric samples are allowed to sit for at least 30 minutes in the polymer solutions. The fabric samples are removed from the polymer solutions and rinsed in DI water for at least one minute to remove any unbound polymer. The fabric samples are then dried at 60 °C for at least 30 minutes until constant dryness is achieved. The fabric samples are weighed after drying and individually placed in 2-mL wells in a clean 48-well cell culture plate. The fabric samples are then exposed to 1 mL of a 250 ppm Direct Red 80 dye solution. The samples are left in the dye solution for at least 15 minutes. Each fabric sample is removed from the dye solution, after which the dye solution is diluted 10x.

The absorbance of the diluted solutions is measured compared to a control sample. A relative measure of glucan polymer adsorbed to the fabric is calculated based on the calibration curve created in Example 19 for Direct Red 80 dye. Specifically, the difference in UV absorbance for

the fabric samples exposed to polymer compared to the controls (fabric not exposed to polymer) represents a relative measure of polymer adsorbed to the fabric. This difference in UV absorbance could also be expressed as the amount of dye bound to the fabric (over the amount of dye bound to control), which is calculated using the calibration curve (i.e., UV absorbance is converted to ppm dye). A positive value represents the dye amount that is in excess to the dye amount bound to the control fabric, whereas a negative value represents the dye amount that is less than the dye amount bound to the control fabric. A positive value would reflect that the glucan ether compound adsorbed to the fabric surface.

It is believed that this assay would demonstrate that quaternary ammonium glucan can adsorb to various types of fabric under different salt and pH conditions. This adsorption would suggest that cationic glucan ether derivatives are useful in detergents for fabric care (e.g., as anti-redeposition agents).

EXAMPLE 23

Adsorption of the Present α -Glucan Fiber Compositions on Various Fabrics

This example discloses how one could test the degree of adsorption of the present α -glucan oligomer/polymer composition (unmodified) on different types of fabrics.

A 0.07 wt% solution of the present α -glucan oligomer/polymer composition (as prepared in Examples 6 or 7) is made by dissolving 0.105 g of the polymer in 149.89 g of deionized water. This solution is divided into several aliquots with different concentrations of polymer (Table 13). Other components are added such as acid (dilute hydrochloric acid) or base (sodium hydroxide) to modify pH, or NaCl salt.

Table 13

α -Glucan Fiber Solutions Useful in Fabric Adsorption Studies

| Amount of NaCl (g) | Amount of Solution (g) | Polymer Concentration (wt%) | Final pH |
|--------------------|------------------------|-----------------------------|----------|
| 0 | 15 | 0.07 | ~7 |
| 0.15 | 14.85 | 0.0693 | ~7 |

| | | | |
|------|---------|--------|-----|
| 0.3 | 14.7 | 0.0686 | ~7 |
| 0.45 | 14.55 | 0.0679 | ~7 |
| 0 | 9.7713 | 0.0683 | ~3 |
| 0 | 9.7724 | 0.0684 | ~5 |
| 0 | 10.0311 | 0.0702 | ~9 |
| 0 | 9.9057 | 0.0693 | ~11 |

Four different fabric types (cretonne, polyester, 65:35 polyester/cretonne, bleached cotton) are cut into 0.17 g pieces. Each piece is placed in a 2-mL well in a 48-well cell culture plate. Each fabric sample is exposed to 1 mL of each of the above solutions (Table 13) for a total of 36 samples (a control solution with no polymer is included for each fabric test). The fabric samples are allowed to sit for at least 30 minutes in the polymer solutions. The fabric samples are removed from the polymer solutions and rinsed in DI water for at least one minute to remove any unbound polymer. The fabric samples are then dried at 60 °C for at least 30 minutes until constant dryness is achieved. The fabric samples are weighed after drying and individually placed in 2-mL wells in a clean 48-well cell culture plate. The fabric samples are then exposed to 1 mL of a 250 ppm Direct Red 80 dye solution. The samples are left in the dye solution for at least 15 minutes. Each fabric sample is removed from the dye solution, after which the dye solution is diluted 10x.

The absorbance of the diluted solutions is measured compared to a control sample. A relative measure of the α -glucan polymer adsorbed to the fabric is calculated based on the calibration curve created in Example 19 for Direct Red 80 dye. Specifically, the difference in UV absorbance for the fabric samples exposed to polymer compared to the controls (fabric not exposed to polymer) represents a relative measure of polymer adsorbed to the fabric. This difference in UV absorbance could also be expressed as the amount of dye bound to the fabric (over the amount of dye bound to control), which is calculated using the calibration curve (i.e., UV absorbance is converted to ppm dye). A positive value represents the dye amount that is in excess to the dye amount bound to the control fabric, whereas a negative value represents the dye amount that is less than the

dye amount bound to the control fabric. A positive value would reflect that the glucan ether compound adsorbed to the fabric surface.

It is believed that this assay would demonstrate that the present α -glucan oligomer/polymer compositions can adsorb to various types of fabric under different salt and pH conditions. This adsorption would suggest that the present α -glucan oligomer/polymer compositions are useful in detergents for fabric care (e.g., as anti-redeposition agents).

EXAMPLE 24

Adsorption of Carboxymethyl α -Glucan (CMG) on Various Fabrics

This example discloses how one could test the degree of adsorption of an α -glucan ether compound (CMG) on different types of fabrics.

A 0.25 wt% solution of CMG is made by dissolving 0.375 g of the polymer in 149.625 g of deionized water. This solution is divided into several aliquots with different concentrations of polymer (Table 14). Other components are added such as acid (dilute hydrochloric acid) or base (sodium hydroxide) to modify pH, or NaCl salt.

Table 14

CMG Solutions Useful in Fabric Adsorption Studies

| Amount of NaCl (g) | Amount of Solution (g) | Polymer Concentration (wt%) | Final pH |
|--------------------|------------------------|-----------------------------|----------|
| 0 | 15 | 0.25 | ~7 |
| 0.15 | 14.85 | 0.2475 | ~7 |
| 0.3 | 14.7 | 0.245 | ~7 |
| 0.45 | 14.55 | 0.2425 | ~7 |
| 0 | 9.8412 | 0.2459 | ~3 |
| 0 | 9.4965 | 0.2362 | ~5 |
| 0 | 9.518 | 0.2319 | ~9 |
| 0 | 9.8811 | 0.247 | ~11 |

Four different fabric types (cretonne, polyester, 65:35 polyester/cretonne, bleached cotton) are cut into 0.17 g pieces. Each piece is placed in a 2-mL well in a 48-well cell culture plate. Each fabric sample is exposed to 1 mL of each of the above solutions (Table 14) for a total of 36 samples (a control solution with no polymer is included for each fabric test). The fabric samples are allowed to sit for at least 30 minutes in

the polymer solutions. The fabric samples are removed from the polymer solutions and rinsed in DI water for at least one minute to remove any unbound polymer. The fabric samples are then dried at 60 °C for at least 30 minutes until constant dryness is achieved. The fabric samples are weighed after drying and individually placed in 2-mL wells in a clean 48-well cell culture plate. The fabric samples are then exposed to 1 mL of a 250 ppm Toluidine Blue dye solution. The samples are left in the dye solution for at least 15 minutes. Each fabric sample is removed from the dye solution, after which the dye solution is diluted 10x.

The absorbance of the diluted solutions is measured compared to a control sample. A relative measure of CMG polymer adsorbed to the fabric is calculated based on the calibration curve created in Example 19 for Toluidine Blue dye. Specifically, the difference in UV absorbance for the fabric samples exposed to polymer compared to the controls (fabric not exposed to polymer) represents a relative measure of polymer adsorbed to the fabric. This difference in UV absorbance could also be expressed as the amount of dye bound to the fabric (over the amount of dye bound to control), which is calculated using the calibration curve (i.e., UV absorbance is converted to ppm dye). A positive value represents the dye amount that is in excess to the dye amount bound to the control fabric, whereas a negative value represents the dye amount that is less than the dye amount bound to the control fabric. A positive value would reflect that the CMG polymer adsorbed to the fabric surface.

It is believed that this assay would demonstrate that CMG polymer can adsorb to various types of fabric under different salt and pH conditions. This adsorption would suggest that the present glucan ether derivatives are useful in detergents for fabric care (e.g., as anti-redeposition agents).

EXAMPLE 25

Effect of Cellulase on Carboxymethyl Glucan (CMG)

This example discloses how one could test the stability of an α -glucan ether, CMG, in the presence of cellulase compared to the stability of carboxymethyl cellulose (CMC). Stability to cellulase would indicate

applicability of CMG to use in cellulase-containing compositions/processes such as in fabric care.

Solutions (1 wt%) of CMC ($M_w = 90000$, DoS = 0.7) or CMG are treated with cellulase or amylase as follows. CMG or CMC polymer (100 mg) is added to a clean 20-mL glass scintillation vial equipped with a PTFE stir bar. Water (10.0 mL) that has been previously adjusted to pH 7.0 using 5 vol% sodium hydroxide or 5 vol% sulfuric acid is then added to the scintillation vial, and the mixture is agitated until a solution (1 wt%) forms. A cellulase or amylase enzyme is added to the solution, which is then agitated for 24 hours at room temperature ($\sim 25^\circ\text{C}$). Each enzyme-treated sample is analyzed by SEC (above) to determine the molecular weight of the treated polymer. Negative controls are conducted as above, but without the addition of a cellulase or amylase. Various enzymatic treatments of CMG and CMC that could be performed are listed in Table 15, for example.

Table 15

Measuring Stability of CMG and CMC Against Degradation by Cellulase or

Amylase

| Polyme r | Enzyme | Enzyme Type | Enzyme Loading |
|---------------------|---------------------|------------------------|---------------------------|
| CMC | none | N/A | - |
| CMC | PURADAX HA 1200E | Cellulase | 1 mg/mL |
| CMC | PREFERENZ S 100 | Amylase | 3 $\mu\text{L}/\text{mL}$ |
| | | | |
| CMG | none | N/A | - |
| CMG | PURADAX HA 1200E | Cellulase | 1 mg/mL |
| CMG | PREFERENZ S 100 | Amylase | 3 $\mu\text{L}/\text{mL}$ |
| CMG | PURASTAR ST L | Amylase | 3 $\mu\text{L}/\text{mL}$ |
| CMG | PURADAX EG L | Cellulase | 3 $\mu\text{L}/\text{mL}$ |

It is believed that the enzymatic studies in Table 15 would indicate that CMC is highly susceptible to degradation by cellulase, whereas CMG

is more resistant to this degradation. It is also believed that these studies would indicate that both CMC and CMG are largely stable to amylase.

Use of CMC for providing viscosity to an aqueous composition (e.g., laundry or dishwashing detergent) containing cellulase would be unacceptable. CMG on the other hand, given its stability to cellulase, would be useful for cellulase-containing aqueous compositions such as detergents.

EXAMPLE 26

Effect of Cellulase on Carboxymethyl Glucan (CMG)

This example discloses how one could test the stability of the present α -glucan oligomer/polymer composition (unmodified) in the presence of cellulase compared to the stability of carboxymethyl cellulose (CMC). Stability to cellulase would indicate applicability of the present α -glucan oligomer/polymer composition to use in cellulase-containing compositions/processes, such as in fabric care.

Solutions (1 wt%) of CMC ($M_w = 90000$, DoS = 0.7) or the present α -glucan oligomer/polymer composition as described in Examples 6 or 7 are treated with cellulase or amylase as follows. The present α -glucan oligomer/polymer composition or CMC polymer (100 mg) is added to a clean 20-mL glass scintillation vial equipped with a PTFE stir bar. Water (10.0 mL) that has been previously adjusted to pH 7.0 using 5 vol% sodium hydroxide or 5 vol% sulfuric acid is then added to the scintillation vial, and the mixture is agitated until a solution (1 wt%) forms. A cellulase or amylase enzyme is added to the solution, which is then agitated for 24 hours at room temperature ($\sim 25^\circ\text{C}$). Each enzyme-treated sample is analyzed by SEC (above) to determine the molecular weight of the treated polymer. Negative controls are conducted as above, but without the addition of a cellulase or amylase. Various enzymatic treatments of the present α -glucan oligomer/polymer composition and CMC that could be performed are listed in Table 16, for example.

Table 16Measuring Stability of an α -Glucan Fiber Composition and CMC Against Degradation by Cellulase or Amylase

| Polymer | Enzyme | Enzyme Type | Enzyme Loading |
|---------------------------|------------------|--------------------|-----------------------|
| CMC | none | N/A | - |
| CMC | PURADAX HA 1200E | Cellulase | 1 mg/mL |
| CMC | PREFERENZ S 100 | Amylase | 3 μ L/mL |
| | | | |
| α -GF ¹ | none | N/A | - |
| α -GF | PURADAX HA 1200E | Cellulase | 1 mg/mL |
| α -GF | PREFERENZ S 100 | Amylase | 3 μ L/mL |
| α -GF | PURASTAR ST L | Amylase | 3 μ L/mL |
| α -GF | PURADAX EG L | Cellulase | 3 μ L/mL |
| | | | |

¹ = α -GF is the present α -glucan fiber.

It is believed that the enzymatic studies in Table 16 would indicate that CMC is highly susceptible to degradation by cellulase, whereas the present α -glucan oligomer/polymer composition is more resistant to this degradation. It is also believed that these studies would indicate that both CMC and the present α -glucan oligomer/polymer composition are largely stable to amylase.

Use of CMC for providing viscosity to an aqueous composition (e.g., laundry or dishwashing detergent) containing cellulase would be unacceptable. The present α -glucan oligomer/polymer composition (unmodified) on the other hand, given its stability to cellulase, would be useful for cellulase-containing aqueous compositions such as detergents.

EXAMPLE 27Preparation of Hydroxypropyl α -Glucan

This Example describes producing the glucan ether derivative, hydroxypropyl α -glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is mixed with 101 g of toluene and 5 mL of 20% sodium hydroxide. This preparation is stirred in a 500-mL glass beaker on a magnetic stir plate at 55 °C for 30 minutes. The preparation is then transferred to a shaker tube reactor after which 34 g of propylene oxide is added; the reaction is then stirred at 75 °C for 3 hours. The reaction is then neutralized with 20 g of acetic acid and the hydroxypropyl α -glucan formed is collected, washed with 70 % aqueous ethanol or hot water, and dried. The molar substitution (MS) of the product is determined by NMR.

EXAMPLE 28

Preparation of Hydroxyethyl α -Glucan

This Example describes producing the glucan ether derivative, hydroxyethyl poly α -1,3-glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is mixed with 150 mL of isopropanol and 40 mL of 30% sodium hydroxide. This preparation is stirred in a 500-mL glass beaker on a magnetic stir plate at 55 °C for 1 hour, and then is stirred overnight at ambient temperature. The preparation is then transferred to a shaker tube reactor after which 15 g of ethylene oxide is added; the reaction is then stirred at 60 °C for 6 hour. The reaction is then allowed to remain in the sealed shaker tube overnight (approximately 16 hours) before it is neutralized with 20.2 g of acetic acid thereby forming hydroxyethyl glucan. The hydroxyethyl glucan solids is collected and is washed in a beaker by adding a methanol:acetone (60:40 v/v) mixture and stirring with a stir bar for 20 minutes. The methanol:acetone mixture is then filtered away from the solids. This washing step is repeated two times prior to drying of the product. The molar substitution (MS) of the product is determined by NMR.

EXAMPLE 29

Preparation of Ethyl α -Glucan

This Example describes producing the glucan ether derivative, ethyl glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is added to a shaker tube, after which sodium hydroxide (1-70% solution) and ethyl chloride are added to provide a reaction. The reaction is heated to 25-200 °C and held at that temperature for 1-48 hours before the reaction is neutralized with acetic acid. The resulting product is collected washed, and analyzed by NMR and SEC to determine the molecular weight and degree of substitution (DoS) of the ethyl glucan.

EXAMPLE 30

Preparation of Ethyl Hydroxyethyl α -Glucan

This Example describes producing the glucan ether derivative, ethyl hydroxyethyl glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is added to a shaker tube, after which sodium hydroxide (1-70% solution) is added. Then, ethyl chloride is added followed by an ethylene oxide/ethyl chloride mixture to provide a reaction. The reaction is slowly heated to 25-200 °C and held at that temperature for 1-48 hours before being neutralized with acetic acid. The product formed is collected, washed, dried under a vacuum at 20-70 °C, and then analyzed by NMR and SEC to determine the molecular weight and DoS of the ethyl hydroxyethyl glucan.

EXAMPLE 31

Preparation of Methyl α -Glucan

This Example describes producing the glucan ether derivative, methyl glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is mixed with 40 mL of 30% sodium hydroxide and 40 mL of 2-propanol, and is stirred at 55 °C for 1 hour to provide alkali glucan. This preparation is then filtered, if needed, using a Buchner funnel. The alkali glucan is then mixed with 150 mL of 2-propanol. A shaker tube reactor is charged with the mixture and 15 g of methyl chloride is added to provide a reaction. The reaction is stirred at 70 °C for 17 hours. The resulting methyl glucan solid is filtered and neutralized with 20 mL 90% acetic acid, followed by three 200-mL ethanol

washes. The resulting product is analyzed by NMR and SEC to determine the molecular weight and degree of substitution (DoS).

EXAMPLE 32

Preparation of Hydroxyalkyl Methyl α -Glucan

This Example describes producing the glucan ether derivative, hydroxyalkyl methyl α -glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is added to a vessel, after which sodium hydroxide (5-70% solution) is added. This preparation is stirred for 0.5-8 hours. Then, methyl chloride is added to the vessel to provide a reaction, which is then heated to 30-100 °C for up to 14 days. An alkylene oxide (e.g., ethylene oxide, propylene oxide, butylene oxide, etc.) is then added to the reaction while controlling the temperature. The reaction is heated to 25-100 °C for up to 14 days before being neutralized with acid. The product thus formed is filtered, washed and dried. The resulting product is analyzed by NMR and SEC to determine the molecular weight and degree of substitution (DoS).

EXAMPLE 33

Preparation of Carboxymethyl Hydroxyethyl α -Glucan

This Example describes producing the glucan ether derivative, carboxymethyl hydroxyethyl glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is added to an aliquot of a substance such as isopropanol or toluene in a 400-mL capacity shaker tube, after which sodium hydroxide (1-70% solution) is added. This preparation is stirred for up to 48 hours. Then, monochloroacetic acid is added to provide a reaction, which is then heated to 25-100 °C for up to 14 days. Ethylene oxide is then added to the reaction, which is then heated to 25-100 °C for up to 14 days before being neutralized with acid (e.g., acetic, sulfuric, nitric, hydrochloric, etc.). The product thus formed is collected, washed and dried. The resulting product is analyzed by NMR and SEC to determine the molecular weight and degree of substitution (DoS).

EXAMPLE 34

Preparation of Sodium Carboxymethyl Hydroxyethyl α -Glucan

This Example describes producing the glucan ether derivative, sodium carboxymethyl hydroxyethyl glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is added to an aliquot of an alcohol such as isopropanol in a 400-mL capacity shaker tube, after which sodium hydroxide (1-70% solution) is added. This preparation is stirred for up to 48 hours. Then, sodium monochloroacetate is added to provide a reaction, which is then heated to 25-100 °C for up to 14 days. Ethylene oxide is then added to the reaction, which is then heated to 25-100 °C for up to 14 days before being neutralized with acid (e.g., acetic, sulfuric, nitric, hydrochloric, etc.). The product thus formed is collected, washed and dried. The resulting product is analyzed by NMR and SEC to determine the molecular weight and degree of substitution (DoS).

EXAMPLE 35

Preparation of Carboxymethyl Hydroxypropyl α -Glucan

This Example describes producing the glucan ether derivative, carboxymethyl hydroxypropyl glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is added to an aliquot of a substance such as isopropanol or toluene in a 400-mL capacity shaker tube, after which sodium hydroxide (1-70% solution) is added. This preparation is stirred for up to 48 hours. Then, monochloroacetic acid is added to provide a reaction, which is then heated to 25-100 °C for up to 14 days. Propylene oxide is then added to the reaction, which is then heated to 25-100 °C for up to 14 days before being neutralized with acid (e.g., acetic, sulfuric, nitric, hydrochloric, etc.). The solid product thus formed is collected, washed and dried. The resulting product is analyzed by NMR and SEC to determine the molecular weight and degree of substitution (DoS).

EXAMPLE 36

Preparation of Sodium Carboxymethyl Hydroxypropyl α -Glucan

This Example describes producing the glucan ether derivative, sodium carboxymethyl hydroxypropyl glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is added to an aliquot of a substance such as isopropanol or toluene in a 400-mL capacity shaker tube, after which sodium hydroxide (1-70% solution) is added. This preparation is stirred for up to 48 hours. Then, sodium monochloroacetate is added to provide a reaction, which is then heated to 25-100 °C for up to 14 days. Propylene oxide is then added to the reaction, which is then heated to 25-100 °C for up to 14 days before being neutralized with acid (e.g., acetic, sulfuric, nitric, hydrochloric, etc.). The product thus formed is collected, washed and dried. The resulting product is analyzed by NMR and SEC to determine the molecular weight and degree of substitution (DoS).

EXAMPLE 37

Preparation of Potassium Carboxymethyl α -Glucan

This Example describes producing the glucan ether derivative, potassium carboxymethyl glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is added to 200 mL of isopropanol in a 500-mL capacity round bottom flask fitted with a thermocouple for temperature monitoring and a condenser connected to a recirculating bath, and a magnetic stir bar. 40 mL of potassium hydroxide (15% solution) is added drop wise to this preparation, which is then heated to 25 °C on a hotplate. The preparation is stirred for 1 hour before the temperature is increased to 55 °C. Potassium chloroacetate (12 g) is then added to provide a reaction, which was held at 55 °C for 3 hours before being neutralized with 90% acetic acid. The product formed was collected, washed with ethanol (70%), and dried under vacuum at 20-25 °C. The resulting product is analyzed by NMR and SEC to determine the molecular weight and degree of substitution (DoS).

EXAMPLE 38

Preparation of Lithium Carboxymethyl α -Glucan

This Example describes producing the glucan ether derivative, lithium carboxymethyl glucan.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Examples 6 or 7 is added to 200 mL of isopropanol in a 500-mL capacity round bottom flask fitted with a thermocouple for temperature monitoring and a condenser connected to a recirculating bath, and a magnetic stir bar. 50 mL of lithium hydroxide (11.3% solution) is added drop wise to this preparation, which is then heated to 25 °C on a hotplate. The preparation is stirred for 1 hour before the temperature is increased to 55 °C. Lithium chloroacetate (12 g) is then added to provide a reaction, which is held at 55 °C for 3 hours before being neutralized with 90% acetic acid. The product formed is collected, washed with ethanol (70%), and dried under vacuum at 20-25 °C. The resulting product is analyzed by NMR and SEC to determine the molecular weight and degree of substitution (DoS).

EXAMPLE 39

Preparation of a Dihydroxyalkyl α -Glucan

This Example describes producing a dihydroxyalkyl ether derivative of α -glucan. Specifically, dihydroxypropyl glucan is produced.

Approximately 10 g of the present α -glucan oligomer/polymer composition as prepared in Example 6 or 7 is added to 100 mL of 20% tetraethylammonium hydroxide in a 500-mL capacity round bottom flask fitted with a thermocouple for temperature monitoring and a condenser connected to a recirculating bath, and a magnetic stir bar (resulting in ~9.1 wt% poly α -1,3-glucan). This preparation is stirred and heated to 30 °C on a hotplate. The preparation is stirred for 1 hour to dissolve any solids before the temperature is increased to 55 °C. 3-chloro-1,2-propanediol (6.7 g) and 11 g of DI water were then added to provide a reaction (containing ~5.2 wt% 3-chloro-1,2-propanediol), which is held at 55 °C for 1.5 hours after which time 5.6 g of DI water is added to the reaction. The reaction is held at 55 °C for an additional 3 hours and 45 minutes before being neutralized with acetic acid. After neutralization, an

excess of isopropanol is added. The product formed was collected, washed with ethanol (95%), and dried under vacuum at 20-25 °C. The resulting product is analyzed by NMR and SEC to determine the molecular weight and degree of substitution (DoS).

CLAIMS

What is claimed is:

1. A fabric care composition comprising:
 - a. an α -glucan oligomer/polymer composition comprising:
 - i. 25-35 α -(1,3) glycosidic linkages;
 - ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons;
 - v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - vi. a solubility of at least 20% (w/w) in water at 25 °C; and
 - vii. a polydispersity index of less than 5; and
 - b. at least one additional fabric care ingredient.
2. A laundry care composition comprising:
 - a. an α -glucan oligomer/polymer composition comprising:
 - i. 25-35 α -(1,3) glycosidic linkages;
 - ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons;
 - v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - vi. a solubility of at least 20% (w/w) in water at 25 °C; and
 - vii. a polydispersity index of less than 5; and
 - b. at least one additional laundry care ingredient.
3. The fabric care composition of claim 1 or the laundry care composition of claim 2, wherein the additional ingredient is at least one cellulase.

4. The fabric care composition of claim 1 or the laundry care composition of claim 2, wherein the additional ingredient is at least one protease.
5. The fabric care composition of claim 1 or the laundry care composition of claim 2, wherein the soluble α -glucan oligomer/polymer composition comprises less than 4% α -(1,4) glycosidic linkages.
6. The fabric care composition of claim 1 or the laundry care composition of claim 2, wherein the fabric care or laundry care composition comprises 0.01 to 90% wt% of the soluble α -glucan oligomer/polymer composition.
7. The fabric care composition of claim 1, where the at least one additional fabric care ingredient comprises at least one of surfactants (anionic, nonionic, cationic, or zwitterionic), enzymes (proteases, cellulases, polyesterases, amylases, cutinases, lipases, pectate lyases, perhydrolases, xylanases, peroxidases, and/or laccases in any combination), detergent builders, complexing agents, polymers (in addition to the present α -glucan oligomers/polymers and/or α -glucan ethers), soil release polymers, surfactancy-boosting polymers, bleaching systems, bleach activators, bleaching catalysts, fabric conditioners, clays, foam boosters, suds suppressors (silicone or fatty-acid based), anti-corrosion agents, soil-suspending agents, anti-soil redeposition agents, dyes, bactericides, tarnish inhibitors, optical brighteners, perfumes, saturated or unsaturated fatty acids, dye transfer inhibiting agents, chelating agents, hueing dyes, calcium and magnesium cations, visual signaling ingredients, anti-foam, structurants, thickeners, anti-caking agents, starch, sand, gelling agents, and any combination thereof.
8. The laundry care composition of claim 2, where the at least one additional laundry care ingredient comprises at least one of surfactants (anionic, nonionic, cationic, or zwitterionic), enzymes (proteases, cellulases, polyesterases, amylases, cutinases, lipases, pectate lyases,

perhydrolases, xylanases, peroxidases, and/or laccases in any combination), detergent builders, complexing agents, polymers (in addition to the present α -glucan oligomers/polymers and/or α -glucan ethers), soil release polymers, surfactancy-boosting polymers, bleaching systems, bleach activators, bleaching catalysts, fabric conditioners, clays, foam boosters, suds suppressors (silicone or fatty-acid based), anti-corrosion agents, soil-suspending agents, anti-soil redeposition agents, dyes, bactericides, tarnish inhibitors, optical brighteners, perfumes, saturated or unsaturated fatty acids, dye transfer inhibiting agents, chelating agents, hueing dyes, calcium and magnesium cations, visual signaling ingredients, anti-foam, structurants, thickeners, anti-caking agents, starch, sand, gelling agents, and any combination thereof.

9. The fabric care composition of claim 1 or the laundry care composition of claim 2, wherein the composition is in the form of a liquid, a gel, a powder, a hydrocolloid, an aqueous solution, granules, tablets, capsules, single compartment sachets, multi-compartment sachets, or any combination thereof.
10. The fabric care composition of claim 1 or the laundry care composition of claim 2, wherein the α -glucan oligomer/polymer composition is cellulase resistant, protease resistant or a combination thereof.
11. A glucan ether composition comprising:
 - a. 25-35 α -(1,3) glycosidic linkages;
 - b. 55-75% α -(1,6) glycosidic linkages;
 - c. 5-15% α -(1,3,6) glycosidic linkages;
 - d. a weight average molecular weight of less than 5000 Daltons;
 - e. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - f. a solubility of at least 20% (w/w) in water at 25 °C; and

- g. a polydispersity index of less than 5; wherein the glucan ether composition has a degree of substitution (DoS) with at least one organic group of about 0.05 to about 3.0.
- 12. The glucan ether composition of claim 11, wherein the composition has a degree of substitution (DoS) with at least one organic group of about 0.05 to about 3.0.
 - 13. The glucan ether composition of claim 11, wherein at least one organic group is selected from the group consisting of carboxy alkyl group, hydroxy alkyl group, and alkyl group.
 - 14. The glucan ether composition of claim 11, wherein at least one organic group is selected from the group consisting of carboxymethyl, hydroxypropyl, dihydroxypropyl, hydroxyethyl, methyl, and ethyl group.
 - 15. The glucan ether composition of claim 11, wherein at least one organic group is a positively charged organic group.
 - 16. The glucan ether composition of claim 11, wherein the glucan ether is a quaternary ammonium glucan ether.
 - 17. The glucan ether composition of claim 16, wherein the quaternary ammonium glucan ether is a trimethylammonium hydroxypropyl glucan.
 - 18. The glucan ether composition 11, wherein the glucan ether composition is cellulase resistant, protease resistant or a combination thereof.
 - 19. A personal care composition, fabric care composition or laundry care composition comprising the glucan ether composition of claim 11.
 - 20. A method of treating an article of clothing, textile or fabric comprising:
 - a. providing a composition selected from

- i. the fabric care composition of claim 1;
 - ii. the laundry care composition of claim 2;
 - iii. the glucan ether composition of claim 11;
 - iv. the α -glucan oligomer/polymer composition comprising:
 - 1. 25-35 α -(1,3) glycosidic linkages;
 - 2. 55-75% α -(1,6) glycosidic linkages;
 - 3. 5-15% α -(1,3,6) glycosidic linkages;
 - 4. a weight average molecular weight of less than 5000 Daltons;
 - 5. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - 6. a solubility of at least 20% (w/w) in water at 25 °C; and
 - 7. a polydispersity index of less than 5; and
 - v. any combination of (i) through (iv).
- b. contacting under suitable conditions the composition of (a) with a fabric, textile or article of clothing whereby the fabric, textile or article of clothing is treated and receives a benefit;
 - c. optionally rinsing the treated fabric, textile or article of clothing of (b).
21. The method of claim 20, wherein the composition of (a) is cellulase resistant, protease resistant, amylase resistant or a combination thereof.
22. The method of claim 20, wherein the α -glucan oligomer/polymer composition or the α -glucan ether composition is a surface substantive.
23. The method of claim 20, wherein the benefit is selected from the group consisting of improved fabric hand, improved resistance to soil deposition, improved colorfastness, improved wear resistance, improved wrinkle resistance, improved antifungal activity, improved stain resistance, improved cleaning performance when laundered,

improved drying rates, improved dye, pigment or lake update, and any combination thereof.

24. A method to produce a glucan ether composition comprising:

- a. providing an α -glucan oligomer/polymer composition comprising:
 - i. 25-35 α -(1,3) glycosidic linkages;
 - ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons;
 - v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - vi. a solubility of at least 20% (w/w) in water at 25 °C; and
 - vii. a polydispersity index of less than 5;
- b. contacting the α -glucan oligomer/polymer composition of (a) in a reaction under alkaline conditions with at least one etherification agent comprising an organic group; whereby an α -glucan ether is produced has a degree of substitution (DoS) with at least one organic group of about 0.05 to about 3.0; and
- c. optionally isolating the α -glucan ether produced in step (b).

25. The method of claim 24, wherein said organic group is a hydroxy alkyl group, alkyl group, or carboxy alkyl group.

26. A textile, yarn, fabric or fiber comprising

- a. an α -glucan oligomer/polymer composition comprising:
 - i. 25-35 α -(1,3) glycosidic linkages;
 - ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons;
 - v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - vi. a solubility of at least 20% (w/w) in water at 25 °C; and

- vii. a polydispersity index of less than 5;
 - b. a glucan ether composition comprising
 - i. 25-35 α -(1,3) glycosidic linkages;
 - ii. 55-75% α -(1,6) glycosidic linkages;
 - iii. 5-15% α -(1,3,6) glycosidic linkages;
 - iv. a weight average molecular weight of less than 5000 Daltons;
 - v. a viscosity of less than 0.25 Pascal second (Pa•s) at 12 wt% in water 20°C;
 - vi. a solubility of at least 20% (w/w) in water at 25 °C; and
 - vii. a polydispersity index of less than 5;wherein the glucan ether composition has a degree of substitution (DoS) with at least one organic group of about 0.05 to about 3.0 or
 - c. a combination thereof.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060839

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| A. CLASSIFICATION OF SUBJECT MATTER INV. C08B37/00 C08L5/00 C11D3/22 C11D7/26 C11D11/00 ADD. | | |
| According to International Patent Classification (IPC) or to both national classification and IPC | | |
| B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) C08B C08L C11D | | |
| Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched | | |
| Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, BIOSIS, CHEM ABS Data, COMPENDEX, EMBASE, WPI Data | | |
| C. DOCUMENTS CONSIDERED TO BE RELEVANT | | |
| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| X | WO 2015/123323 A1 (DU PONT [US]) 20 August 2015 (2015-08-20) the whole document in particular: abstract; page 2, line 4 - page 4, line 22; page 12, line 3 - page 13, line 6; page 19, lines 1-13; page 31, line 25 - page 32, line 18; page 47, line 13 - page 48, line 10; page 51, line 30 - page 54, line 15; page 60, line 11 - page 66, line 29; page 82, line 27 - page 101, line 27; claims 1-16; examples; tables <div style="text-align: center;">----- -/-</div> | 1-26 |
| <div style="display: flex; justify-content: space-between;"> <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex. </div> | | |
| <div style="display: flex;"> <div style="flex: 1;"> <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="flex: 1;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p> </div> </div> | | |
| Date of the actual completion of the international search <div style="text-align: center; font-size: 1.2em;">24 March 2017</div> | | Date of mailing of the international search report <div style="text-align: center; font-size: 1.2em;">03/04/2017</div> |
| Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016 | | Authorized officer <div style="text-align: center; font-size: 1.2em;">Ferreira, Roger</div> |

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International application No

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