specific process (Datta *et al*., Enzyme immobilization: an overview on techniques and support materials. 3 Biotech (2013), 3:1-9). Therefore, unique solutions must be developed for each process.

[0005] The enzymes in commercial processes can be adsorbed on insoluble organic or inorganic supports commonly used to improve functionality, as known in the art. These include polymeric supports such as agarose, methacrylate, polystyrene, phenol formaldehyde, or dextran, as well as inorganic supports such as glass, metal, or carbon-based materials. These materials are often produced with large surface-to-volume ratios and specialized surfaces that promote attachment and activity of immobilized enzymes. The enzymes might be affixed to these solid supports through covalent, ionic, or hydrophobic interactions. The enzymes could also be affixed through genetically engineered interactions such as covalent fusion to another protein or peptide sequence with affinity to the solid support, most often a polyhistidine sequence. The enzymes might be affixed either directly to the surface or surface coating, or they might be affixed to other proteins already present on the surface or surface coating. The enzymes can be immobilized all on one carrier, on individual carriers, or a combination of the two (e.g., two enzyme per carrier then mix those carriers). These variations can be mixed evenly or in defined layers to optimize turnover in a continuous reactor. These enzymes may be mixed evenly or in defined layers or zones to optimize turnover. For example, the beginning of the reactor may have a layer of aGP to ensure a high initial G1P increase. Enzymes may be immobilized all on one carrier bead, each on an individual carrier bead, or in groups of enzymes on a carrier bead. Similarly the enzymes may be immobilized on a specific carrier or multiple carriers within one process using one or more immobilization methodologies.

[0006] There is a need to have improved processes for the production of hexoses that allows for scalability and reuseable enzyme compositions while achieving high yields of the desired hexose.

Summary

[0007] The disclosure relates to immobilized enzyme compositions for the preparation of a hexose. Hexoses include, for example, tagatose, psicose, fructose, allose, mannose, galactose, altrose, talose, sorbose, gulose, idose, and inositol. In one aspect, an immobilized enzyme composition of the disclosure comprises, consists essentially of, or consists of at least two, at least three, at least four, at least five, at least six carriers, at least seven, or at least eight of the following enzymes immobilized to at least one carrier or a mixture of carriers:

a) α glucan phosphorylase (αGP), phosphoglucomutase (PGM), and optionally 1,4-glucan transferase (4-GT); and

b) an enzyme from within a combination of enzymes selected from:

(i) phosphoglucoisomerase (PGI), fructose-6-phosphate epimerase (F6PE), and tagatose-6-phosphate phosphatase (T6PP) to prepare tagatose;

(ii) phosphoglucoisomerase (PGI), piscose-6-phosphate epimerase (P6PE), and picose-6-phosphate phosphatase (P6PP) to prepare allulose;

(iii) phosphoglucoisomerase (PGI), P6PE, allose-6-phosphate isomerase (A6PI), and allose-6-phosphate phosphatase (A6PP) to prepare allose;

(iv) phosphoglucoisomerase (PGI), mannose-6-phosphate isomerase (M6PI) or phosphoglucose/phosphomannose isomerase (PGPMI), and mannose 6-phosphate phosphatase (M6PP) to prepare mannose;

(v) phosphoglucoisomerase (PGI), F6PE, galactose 6-phosphate isomerase (Gal6PI), and galactose 6-phosphate phosphatase (Gal6PP) to prepare galactose;

(vi) PGI and fructose 6-phosphate phosphatase (F6PP) to prepare fructose;

(vii) PGI, P6PE, altrose 6-phosphate isomerase (Alt6PI), and altrose 6-phosphate phosphatase (Alt6PP) to prepare altrose;

(viii) PGI, F6PE, talose 6-phosphate isomerase (Tal6PI), and talose 6-phosphate phosphatase (Tal6PP) to prepare talose;

(ix) PGI, F6PE, sorbose 6-phosphate epimerase (S6PE), and sorbose 6-phosphate phosphatase (S6PP) to prepare sorbose;

(x) PGI, F6PE, S6PE, gulose 6-phosphate isomerase (Gul6PI), and gulose 6-phosphate phosphatase (Gul6PP) to prepare gulose;

(xi) PGI, F6PE, S6PE, idose 6-phosphate isomerase (I6PI), and idose 6-phosphate phosphatase (I6PP) to prepare idose; and

(xii) inositol 3-phosphate synthase (IPS) and inositol monophosphatase (IMP) to prepare inositol.

In an immobilized enzyme composition of the disclosure the weight of each enzyme relative to the total weight of the enzymes (w/w)% ranges from 0.1% to 40%.

[0008] In another aspect, the disclosure also relates to an enzymatic process for preparing a hexose from a saccharide by contacting a starch derivative with an immobilized enzyme composition of the disclosure under suitable reaction conditions convert the starch derivative to the hexose.

Brief Description of the Figures

[0009] FIG. 1A is a graph showing the amounts of enzyme in an immobilized enzyme composition that is optimized for tagatose production.

[0010] FIG. 1B is a graph showing the amounts of enzyme in an immobilized enzyme composition in which the amounts are normalized based on the observed reaction rate of each enzyme relative to T6PP activity in order to have equal units of activity within the cascade.