inhibitor, de-icer, medication, and cancer treatment. The ban on the use of phosphates in detergents due to their toxic nature has increased glucaric acid demand in this segment. Although it is currently produced at lower scale relative to D-gluconic acid, the only sugar acid in high commercial production, glucaric acid is considered to have great potential as a future petrochemical replacement. Guluronic acid may be substituted for glucaric acid in any of the above applications. In addition, the L-guluronate monomer may be useful as a nonsteroidal anti-inflammatory drug.

[0007] The two main methods of generating glucaric acid for commercial use are 1) nitric acid oxidation and 2) palladium or platinum catalyst oxidation. Nitric acid oxidation generates a significant amount of hazardous nitrogen oxide (NOx) gas and is highly exothermic leading to controllability issues. A microbial method of producing high-purity glucaric acid using *S. cerevisiae* myo-inositol-1-phosphate synthase, mouse myo-inositol oxygenase, and *P. syringae* uronate dehydrogenase was developed. Microbial methods, however, can suffer from product separation issues leading to high chemical costs, limiting usage as a commodity chemical.

[0008] An ongoing need exists for novel compositions, methods and processes for the production of high purity sugar acids.

SUMMARY

[0008a] In one aspect, provided herein is a chemoenzymatic process for the preparation of an oxidized glucose product comprising: contacting D-glucose with an enzyme selected from the group consisting essentially of galactose oxidase (GAO), glucose oxidase (GOX), polysaccharide monooxygenase, catalase, animal peroxidase, periplasmic aldehyde oxidase (Pao), unspecific peroxygenase (UPO), lactoperoxidase (LPO), myeloperoxidase (MPO), eosinophil peroxidase (EPO), thyroid peroxidase (TPO), ovoperoxidase, salivary peroxidase, vanadium haloperoxidase, non-mammalian vertebrate peroxidase (POX), peroxidasin (Pxd), bacterial peroxicin (Pxc), invertebrate peroxinectin (Pxt), short peroxidockerin (PxDo), alpha-dioxygenase (aDox), dual oxidase (DuOx), prostaglandin H synthase (PGHS), cyclooxygenase (CyOx), linoleate diol synthase (LDS), variants thereof, and combinations thereof under conditions suitable for the formation of an oxidized intermediate; and contacting the oxidized intermediate with a metal catalyst to form an oxidized glucose product.

[0008b] In another aspect, provided herein is a chemoenzymatic process for the production of glucaric acid comprising:

contacting glucose with a galactose oxidase having any of SEQ ID NO.:6 to SEQ ID NO.:11. under conditions suitable for formation of D-glucohexodialdose; contacting D-glucohexodialdose with a glucose oxidase having SEQ ID NO.:3 under conditions suitable for formation of L-guluronic acid-δ-2,6-lactone; and contacting L-guluronic acid-δ-2,6-lactone with a heterogeneous metal catalyst under conditions suitable for the formation of glucaric acid.

[0008c] In another aspect, provided herein is a chemoenzymatic process for the production of D-glucono-δ-1,5-lactone comprising: contacting glucose with a galactose oxidase having any of SEQ ID NO.:6 to SEQ ID NO.:11. and a glucose oxidase having SEQ ID NO.:3 under conditions suitable for the formation of D-glucono-δ-1,5-lactone.

[0008d] In yet another aspect, provided herein is a chemoenzymatic process for the production of glucaric acid comprising: acidifying D-glucono-δ-1,5-lactone to form L-gluconate; contacting L-gluconate with a galactose oxidase having any of SEQ ID NO.:6 to SEQ ID NO.:11. and a glucose oxidase having SEQ ID NO.:3 under conditions suitable for the formation of L-guluronate: and contacting L-guluronate with a heterogeneous metal catalyst to form glucaric acid.

[0008e] In another aspect, provided herein is a chemoenzymatic process for the production of glucaric acid comprising: contacting a polysaccharide monooxygenase having SEQ ID NO.:4. under conditions suitable for formation of saccharic acid lactone; and hydrolyzing saccharic acid lactone at a pH of greater than about 7 to form glucaric acid.

[0008f] In another aspect, provided herein is a chemoenzymatic process for the production of glucaric acid comprising: contacting glucose with an enzyme composition comprising a glucose oxidase having SEQ ID NO.:3, a peroxidase, halide ions, and a nitroxyl radical mediator, under conditions suitable for the formation to form an oxidized glucose intermediate; and contacting the oxidized glucose intermediate with a heterogeneous catalyst under conditions suitable for the formation of glucaric acid.

[0008g] In yet another aspect, provided herein is a manufacturing process comprising: introducing to a reactor a feedstock comprising glucose and an enzyme selected from the group consisting essentially of galactose oxidase (GAO), glucose oxidase (GOX), polysaccharide monooxygenase, catalase, animal peroxidase, periplasmic aldehyde oxidase (Pao), unspecific peroxygenase (UPO), lactoperoxidase (LPO), myeloperoxidase (MPO), eosinophil peroxidase (EPO), thyroid peroxidase (TPO),

ovoperoxidase, salivary peroxidase, vanadium haloperoxidase, non-mammalian vertebrate peroxidase (POX), peroxidasin (Pxd), bacterial peroxicin (Pxc), invertebrate peroxinectin (Pxt), short peroxidockerin (PxDo), short peroxidockerin (Pxt), alpha-dioxygenase (aDox), dual oxidase (DuOx), prostaglandin H synthase, cyclooxygenase (PGHS/CyOx), linoleate diol synthase (LDS), variants thereof and combinations thereof; operating the reactor under conditions suitable for the formation of a feedstock comprising an oxidized glucose with an aldehyde moiety; transferring the feedstock comprising an oxidized glucose with an aldehyde moiety to another reactor comprising a heterogeneous metal catalyst; and operating the another reactor under conditions suitable for the oxidation of the feedstock.

[0009] Disclosed herein is a chemoenzymatic process for the preparation of an oxidized glucose product comprising contacting D-glucose with an enzyme selected from the group consisting essentially of galactose oxidase (GAO), glucose oxidase (GOX), polysaccharide monooxygenase, catalase, animal peroxidase, periplasmic aldehyde oxidase (Pao), unspecific peroxygenase (UPO), lactoperoxidase (LPO), myeloperoxidase (MPO), eosinophil peroxidase (EPO), thyroid peroxidase (TPO), ovoperoxidase, salivary peroxidase, vanadium haloperoxidase, non-mammalian vertebrate peroxidase (POX), peroxidasin (Pxd), bacterial peroxicin (Pxc), invertebrate peroxinectin (Pxt), short peroxidockerin (PxDo), alpha-dioxygenase (aDox), dual oxidase (DuOx), prostaglandin H synthase (PGHS), cyclooxygenase (CyOx), linoleate diol synthase (LDS), variants thereof, and combinations thereof under conditions suitable for the formation of an oxidized intermediate; and contacting the oxidized intermediate with a metal catalyst to form an oxidized glucose product.

[0010] Also disclosed herein is a chemoenzymatic process for the production of glucaric acid comprising contacting glucose with a galactose oxidase having any of