activity, selectivity and stability necessary for commercial applications. With respect to catalytic activity and selectivity, highly functionalized, biorenewably-derived molecules and intermediates derived from carbohydrates (e.g., glucose and glucaric acid) are non-volatile and must therefore be processed as solutions in the liquid phase. When compared to gas phase catalytic processes, liquid phase catalytic processes are known to suffer from lower productivities because liquid to solid (and gas to liquid to solid) diffusion rates are slower than gas to solid diffusion rates.

[0004] Another challenging aspect associated with the catalytic conversion of highly functionalized biorenewably-derived molecules and intermediates is the use of chemically aggressive reaction conditions. For example, U.S. Patent No. 8,669,397 describes catalytic conversion steps performed at elevated temperatures in the presence of polar solvents such as water and acetic acid. Polar solvents are typically required for the dissolution of non-volatile, highly-functionalized molecules such as glucose and glucaric acid, and elevated temperatures are required for productive and affordable catalytic conversion steps for commodity chemical applications. Therefore, a significant challenge associated with the catalytic conversion of highly functionalized biorenewably-derived molecules and intermediates is catalyst stability. Long term catalyst stability is a necessity for commodity chemical production, meaning that the catalyst must be stable, productive, and selective under reaction conditions for long periods.

[0005] The challenges associated with the development of industrial shaped catalysts, especially in the conversion of biorenewably-derived molecules and intermediates, are a) high productivity and selectivity consistent with an economically viable catalyst at industrial scale, b) mechanical and chemical stability of the shaped catalyst support and c) retention of the catalytically active components by the support and the avoidance of leaching of the catalytically active components into a polar solvent reaction medium. There remains a need for industrially scalable, highly active, selective and stable catalyst supports and catalyst compositions that can satisfy these challenges.

SUMMARY OF THE INVENTION

[0006] Briefly, in one aspect, the present disclosure provides processes for preparing shaped porous carbon products. The processes for preparing a shaped porous carbon product comprise mixing a carbonaceous material and an organic binder to form a carbon-binder mixture, wherein the binder comprises: (i) a saccharide selected from the group consisting of a monosaccharide, a disaccharide, an oligosaccharide, a

carbonaceous material mixture to produce a shaped carbon composite; and heating the shaped carbon composite in a heating zone to carbonize the binder thereby producing the shaped porous carbon product, wherein the heating zone comprises a continuous rotary kiln.

[0010] Further embodiments are directed to processes for preparing a shaped porous carbon product that comprise mixing water, a carbonaceous material, and an organic binder to form a carbon-binder mixture, wherein the binder comprises: (i) a saccharide selected from the group consisting of a monosaccharide, a disaccharide, an oligosaccharide, a derivative thereof, and any combination thereof and/or (ii) a water soluble polymer; forming the carbon-binder mixture to produce a shaped carbon composite; drying the shaped carbon composite at a temperature from about 90°C to about 150°C, from about 100°C to about 150°C, or from about 100°C to about 140°C, wherein the water content of the shaped carbon composite after drying is no greater than about 25 wt.%, no greater than about 20 wt.%, no greater than about 15 wt.%, no greater than about 12 wt.%, no greater than about 11 wt.%, or no greater than about 10 wt.%; and heating the shaped carbon composite in a heating zone to carbonize the binder thereby producing the shaped porous carbon product.

[0011] Still further embodiments are directed to processes for preparing a shaped porous carbon product that comprise mixing water, a carbonaceous material, and an organic binder to form a carbon-binder mixture, wherein the binder comprises: (i) a saccharide selected from the group consisting of a monosaccharide, a disaccharide, an oligosaccharide, a derivative thereof, and any combination thereof and (ii) a water soluble polymer, wherein a 2 wt.% aqueous solution or a 5 wt. % aqueous solution of the water soluble polymer has a viscosity of no greater than about 500 mPa•s, no greater than about 400 mPa•s, no greater than about 300 mPa•s, no greater than about 200 mPa•s, no greater than about 100 mPa•s, no greater than about 75 mPa•s, or no greater than about 50 mPa•s at 25°C and/or the water soluble polymer has a number average molecular weight (M_n) that is no greater than about 50,000 g/mol, no greater than about 40,000 g/mol, no greater than about 30,000 g/mol, no greater than about 25,000 g/mol, or no greater than about 20,000 g/mol; forming the carbon-binder mixture to produce a shaped carbon composite; and heating the shaped carbon composite in a heating zone to carbonize the binder thereby producing the shaped porous carbon product.

[0012] In another aspect, the present disclosure provides shaped porous carbon products. The shaped porous carbon products comprise carbon black and a carbonized binder comprising a carbonization product of an organic binder, wherein the shaped porous carbon product has a BET specific surface area from

about 5 m^2/g to about 500 m^2/g, a mean pore diameter greater than about 10 nm, a specific pore volume greater than about 0.1 cm^3/g, a radial piece crush strength greater than about 4.4 N/mm (1 lb/mm), greater than about 8.8 N/mm (2 lbs/mm), greater than about 13.3 N/mm (3 lbs/mm), greater than about 15 N/mm (3.4 lbs/mm), greater than about 17 N/mm (3.8 lbs/mm), or greater than about 20 N/mm (4.5 lbs/mm), and a carbon black content of at least about 35 wt.%, and wherein the shaped porous carbon product has improved wettability as compared to shaped porous carbon product control 1 as described herein.

[0013] In another aspect, the present disclosure provides shaped porous carbon products comprising a carbon agglomerate comprising a carbonaceous material wherein the shaped porous carbon product has a diameter of at least about 50 μm, a BET specific surface area from about 5 m^2/g to about 500 m^2/g, a mean pore diameter greater than about 10 nm, a specific pore volume greater than about 0.1 cm^3/g, and a radial piece crush strength greater than about 4.4 N/mm (1 lb/mm), greater than about 8.8 N/mm (2 lbs/mm), greater than about 13.3 N/mm (3 lbs/mm), greater than about 15 N/mm (3.4 lbs/mm), greater than about 17 N/mm (3.8 lbs/mm), or greater than about 20 N/mm (4.5 lbs/mm), and wherein the shaped porous carbon product has improved wettability as compared to shaped porous carbon product control 1 as described herein.

[0013a] In another aspect, the present disclosure provides a shaped porous carbon product prepared by the process as mentioned above.

[0013a] In another aspect, the present disclosure provides a process of preparing a catalyst composition, the process comprising the process of preparing a shaped porous carbon product as mentioned above and depositing a catalytically active component or precursor thereof on the shaped porous carbon product.

[0013b] In another aspect, the present disclosure provides a process of preparing a catalyst composition, the process comprising depositing a catalytically active component or precursor thereof on the shaped porous carbon product as mentioned above.

[0013c] In another aspect, the present disclosure provides a catalyst composition comprising a shaped porous carbon product as a catalyst support and a catalytically active component or precursor thereof, wherein the shaped porous carbon product is prepared by the process as mentioned above.

[0013d] In another aspect, the present disclosure provides a catalyst composition comprising the shaped porous carbon product as mentioned above as a catalyst support and a catalytically active component or precursor thereof.

[0014] The present disclosure also provides various catalyst compositions and methods for preparing the catalyst compositions. For example, a catalyst composition according to various embodiments comprises a shaped porous carbon product as a catalyst support and a catalytically active component or precursor thereof at a surface of the support. Another catalyst composition comprises a shaped porous carbon support and a catalytically active component or precursor thereof comprising platinum and gold at a surface of the support. Still another catalyst composition comprises a shaped porous carbon support and a catalytically active component or precursor thereof comprising platinum and rhodium at a surface of the support. Methods of preparing a catalyst composition in accordance with the present disclosure comprise depositing a catalytically active component or precursor thereof on a shaped porous carbon product.

[0015] In other embodiments, the present disclosure is further directed to various processes of using the shaped porous carbon products and the catalyst compositions. One process in accordance with the present disclosure is for the catalytic conversion of a reactant comprising contacting a liquid medium comprising the reactant with a catalyst composition of the present disclosure. Other processes include the selective oxidation of an aldose to an aldaric acid and the selective hydrodeoxygenation of aldaric acid or salt, ester, or lactone thereof to a dicarboxylic

acid. Moreover, the present disclosure is directed to methods of preparing a reactor vessel for a liquid phase catalytic reaction. The methods comprise charging the reactor vessel with a catalyst composition of the present disclosure.

[0016] Other objects and features will be in part apparent and in part pointed out hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 provides a scanning electron microscopy image of the cross-section of a sample of the catalyst extrudate prepared with MONARCH 700 carbon black.

[0018] FIG. 2 provides a magnified view of one of catalyst extrudate cross-sections of FIG. 1.

[0019] FIG. 3 presents a plot of the cumulative pore volume (%) as a function of pore diameter for a raw MONARCH 700 carbon black material.

[0020] FIG. 4 presents a plot of the cumulative pore volume (%) as a function of pore diameter for a fresh catalyst extrudate including the MONARCH 700 carbon black material.

[0021] FIG. 5 presents a plot of the cumulative pore volume (%) as a function of pore diameter for a catalyst extrudate including the MONARCH 700 carbon black material following 350 hours of use.

[0022] FIG. 6 presents a plot of the cumulative pore volume (%) as a function of pore diameter for an extrudate using MONARCH 700 carbon black and a glucose/hydroxyethyl cellulose binder.

[0023] FIG.7 presents a plot of the cumulative pore volume (%) as a function of pore diameter for an extrudate using Sid Richardson SC159 carbon black and a glucose/hydroxyethyl cellulose binder.

[0024] FIG. 8 presents a plot of the cumulative pore volume (%) as a function of pore diameter for an extrudate using Sid Richardson SC 159 carbon black and a glucose/hydroxyethyl cellulose binder which has been exposed to oxygen at 300°C for 3 hours.

[0025] FIG. 9 presents a plot of the cumulative pore volume (%) as a function of pore diameter for an extrudate using Asbury 5368 carbon black and a glucose/hydroxyethyl cellulose binder.

[0026] FIG. 10 presents a plot of the cumulative pore volume (%) as a function of pore diameter for an activated carbon extrudate of Süd Chemie G32H-N-75.

lbs), from about 22 N (5 lbs) to about 66 N (15 lbs), or from about 33 N (7.5 lbs) to about 66 N (15 lbs).

53. The shaped porous carbon product of any one of claims 43 to 52 wherein the shaped porous carbon product has a diameter of at least about 50 μm, at least about 500 μm, at least about 1,000 μm, or at least about 10,000 μm.

54. The shaped porous carbon product of any one of claims 43 to 53 wherein the shaped porous carbon product has a carbonaceous material content from about 35 wt.% to about 80 wt.%, from about 35 wt.% to about 75 wt.%, from about 40 wt.% to about 80 wt.%, or from about 40 wt.% to about 75 wt.% on a dry weight basis.

55. The shaped porous carbon product of any one of claims 43 to 54 wherein the shaped porous carbon product has a carbonized binder content from about 5 wt.% to about 60 wt.%, from about 5 wt.% to about 50 wt.%, from about 5 wt.% to about 40 wt.%, from about 5 wt.% to about 30 wt.%, from about 10 wt.% to about 65 wt.%, from about 10 wt.% to about 60 wt.%, from about 10 wt.% to about 50 wt.%, from about 10 wt.% to about 40 wt.%, from about 10 wt.% to about 30 wt.%, from about 15 wt.% to about 50 wt.%, from about 15 wt.% to about 40 wt.%, from about 15 wt.% to about 35 wt.%, from about 15 wt.% to about 20 wt.%, from about 25 wt.% to about 40 wt.%, or from about 30 wt.% to about 40 wt.%.

56. A shaped porous carbon product prepared by a process according to any one of claims 1 to 42.

57. A process of preparing a catalyst composition, the process comprising:

preparing a shaped porous carbon product according to the process of any one of claims 1 to 42 and

depositing a catalytically active component or precursor thereof on the shaped porous carbon product.

58. A process of preparing a catalyst composition, the process comprising: