# PROCESSING BIOMASS

## RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application Serial No. 61/151,724, filed February 11, 2009. The complete disclosure of this provisional application is hereby incorporated by reference herein.

## BACKGROUND

Various carbohydrates, such as cellulosic and lignocellulosic materials, e.g., in fibrous form, are produced, processed, and used in large quantities in a number of applications. Often such materials are used once, and then discarded as waste, or are simply considered to be waste materials, e.g., sewage, bagasse, sawdust, and stover.

Various cellulosic and lignocellulosic materials, their uses, and applications have been described in U.S. Patent Nos. 7,307,108, 7,074,918, 6,448,307, 6,258,876, 6,207,729, 5,973,035 and 5,952,105; and in various patent applications, including "FIBROUS MATERIALS AND COMPOSITES," PCT/US2006/010648, filed on March 23, 2006, AND "FIBROUS MATERIALS AND COMPOSITES," U.S. Patent Application Publication No. 2007/0045456.

## SUMMARY

Generally, this ~~invention~~ disclosure relates to processes for manufacturing an intermediate or a product, e.g., energy, a fuel such as ethanol, a food or a material, from a plurality of different carbon-containing feedstocks and/or from a feedstock having a variable composition. The carbon-containing feedstock may include, for example, carbohydrate-containing materials (e.g., starchy materials and/or cellulosic or lignocellulosic materials), and may in some cases be a waste material having an unpredictable or variable composition.

In one aspect, a method of producing a treated biomass comprising;

determining the lignin content of a biomass feedstock,

irradiating the feedstock with a dosage of ionizing radiation, and

mechanically treating the biomass feedstock, wherein

the dosage of ionizing radiation is set based on an empirically determined relationship between lignin content of the feedstock, recalcitrance of the feedstock, and dosage of said the ionizing radiation,

thereby providing a treated biomass having reduced recalcitrance relative to the recalcitrance of the biomass feedstock.

The processes disclosed herein, alone or in combination, change the molecular structure and/or recalcitrance level of the feedstock(s), allowing a desired product to be obtained from the feedstock in an economically feasible manner. The inventors have found that the amount of change to the structure and/or recalcitrance level of the feedstock required to produce a product varies as a function of the lignin content of the feedstock. For example, the change in recalcitrance needed can be directly proportional to the lignin content.

utilized to power aircraft, such as planes, e.g., having jet engines, or helicopters. In addition, the products described herein can be utilized for electrical power generation, e.g., in a conventional steam generating plant or in a fuel cell plant.

~~In one aspect,~~ tThe ~~invention~~disclosure also features a method of making a product comprising determining the lignin content of a biomass feedstock; treating the biomass feedstock material with a physical treatment; setting a process parameter of the process based on the lignin content; and converting at least a portion of the treated biomass feedstock, utilizing a microorganism, to produce a product or intermediate, such as energy, fuels, foods or materials.

The physical treatment can be, for example, selected from the group consisting of mechanical treatment, radiation, sonication, pyrolysis, oxidation, steam explosion, chemical treatment, and combinations thereof. Chemical treatment may include the use of a single chemical or two or more chemicals. Mechanical treatments include, for example, cutting, milling, pressing, grinding, shearing and chopping. Milling may include, for example, ball milling, hammer milling, or other types of milling.

Some implementations include one or more of the following features. The physical treatment can comprise any one or more of the treatments listed above, applied alone or in any desired combination, and applied once or multiple times. In some cases, the physical treatment can comprise irradiating with ionizing radiation, alone or accompanied by mechanical treatment before and/or after irradiation. Irradiation can be performed, for example, with an electron beam.

The setting step can comprise setting the dosage of ionizing radiation to be delivered to the feedstock material. For example, a radiation dosage of 0.1 Mrad to 5.0 Mrad can be delivered per 1% by weight of lignin in the biomass feedstock, e.g., 0.25 Mrad to 4.0 Mrad or 0.3 Mrad to 3.5 Mrad.

The intermediate or product can be, for example, any one or more of the products listed herein. In some cases, the product can be energy or a fuel, for example biodiesel or an alcohol such as ethanol or methanol. The intermediate or product can also be, e.g., a carboxylic acid, an ester of a carboxylic acid, a salt of a carboxylic acid, or a mixture thereof.

The method can further include repeating the determining, treating and setting steps with a second feedstock.

~~In another aspect,~~ tThe disclosure also features a method of making a product or intermediate, the method including providing a cellulosic or lignocellulosic material having a plurality of pendent carboxylic acid groups, mixing the material in a fluid that includes water to provide a dispersion that has a first pH, and adding base to the dispersion to increase its pH to a second pH higher than the first pH. The first pH can be, for example, between 2.5 and 4.5, e.g., between 3 and 4.25. The second pH can be, for example, between about 5 and 7, e.g., between about 5.5 and 6.5.

Some implementations include one or more of the following features. The method can further include adding a cellulase to the dispersion to saccharify the cellulosic or lignocellulosic material. The method can further include contacting the saccharified material with a microorganism.

In some implementations, one or more components of the processing equipment, for example the mechanical treatment equipment, chemical (e.g., acid or base) treatment equipment, irradiating equipment, sonicating, pyrolyzing, oxidizing, steam exploding, saccharifying, and/or fermenting equipment, or any of the other equipment described herein, may be portable, e.g., in the manner of the mobile processing equipment described in U.S. Patent Application Serial 12/374,549, and Published International Application No. WO 2008/011598, the full disclosures of which are incorporated herein by reference.

Changing a molecular structure of a material, as used herein, means to change the chemical bonding arrangement or conformation of the structure. For example, the change in the molecular structure can include changing the supramolecular structure of the material, oxidation of the material, changing an average molecular weight, changing an average crystallinity, changing a surface area, changing a degree of polymerization, changing a porosity, changing a degree of branching, grafting on other materials, changing a crystalline domain size, or changing an overall domain size. A change in molecular structure may be effected using any one or more of the physical treatments described herein, alone or in any combination, applied once or repeatedly.

All publications, patent applications, patents, and other references mentioned herein or attached hereto are incorporated by reference in their entirety for all that they contain.

## DESCRIPTION OF THE DRAWINGS