HYDROXYMETHYLFURFURAL REDUCTION METHODS AND METHODS OF PRODUCING FURANDIMETHANOL

RELATED PATENT DATA

This patent is a continuation of U.S. patent application Ser. No. 11/760,634 entitled Hydroxymethylfurfural Reduction Methods and Methods of Producing Furandimethanol which was filed Jun. 8, 2007 now U.S. Pat. No. 7,994,347 and claims priority under 35 U.S.C. §119 to U.S. Provisional Application No. 60/804,409, which was filed Jun. 9, 2006, the entirety of both of which are incorporated by reference herein.

TECHNICAL FIELD

The invention pertains to hydroxymethylfurfural reduction methods, methods of producing furandimethanol, and methods of producing tetrahydrofuran dimethanol.

BACKGROUND OF THE INVENTION

Hydroxymethylfurfural (HMF) is a compound which can be produced from various hexoses or hexose-comprising materials. HMF can in turn be converted into a variety of derivatives, many of which are currently or are quickly becoming commercially valuable. Of particular interest is a reduction product furandimethanol (FDM). Another reduction product of interest is tetrahydrofuran dimethanol (THF dimethanol, alternatively referred to as THF-diol or THFDM). FDM and THF dimethanol are useful in adhesives, sealants, composites, coatings, binders, foams, curatives, polymer materials, solvents, resins or as monomers, for example.

Conventional methodology for production of FDM and/or THF dimethanol from HMF typically results in low yields, and/or low selectivity and can therefore be cost prohibitive. Additionally, conventional methodology often utilizes one or more environmentally unfriendly compound or solvent, or utilizes harsh reaction conditions. Accordingly, it is desirable to develop alternative methods for production of FDM and/or THF dimethanol from HMF.

SUMMARY OF THE INVENTION

In one aspect the invention encompasses a method of reducing HMF where a starting material containing HMF in a solvent comprising water is provided into a reactor. H_2 is provided into a reactor and the starting material is contacted with a catalyst containing at least one metal selected from Ni, Co, Cu, Pd, Pt, Ru, Ir, Re and Rh. The contacting is conducted at a reactor temperature of less than or equal to 250° C.

In one aspect the invention encompasses a method of hydrogenating HMF. An aqueous solution containing HMF and fructose is provided into a reactor and H_2 is provided into the reactor. A hydrogenation catalyst is provided in the reactor. The HMF is selectively hydrogenated relative to the fructose at a temperature at or above about 30° C.

In one aspect the invention pertains to a method of producing tetrahydrofuran dimethanol (THFDM) A feed comprising HMF is provided into a reactor containing a first and a second catalyst. The feed is contacted with the first catalyst to produce furan dimethanol (FDM). The FDM is contacted with the second catalyst to produce THFDM.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are described below with reference to the following accompanying drawings.

FIG. **1** shows conversion of HMF and selective production of furandimethanol and tetrahydrofuran diol (THF diol) as a function of time on stream (TOS) utilizing a continuous flow reactor with a cobalt supported on SiO_2 catalyst and a base set of parameters in accordance with one aspect of the invention.

FIG. **2** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **1** at an increased liquid hourly space velocity (LHSV) relative to FIG. **1**.

FIG. **3** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **1** at a decreased pressure relative to FIG. **1**.

FIG. **4** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **1** at a decreased temperature relative to FIG. **1**.

FIG. **5** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **1** at a decreased temperature relative to FIG. **1**.

FIG. **6** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **1** at a decreased pressure relative to that of FIG. **1**.

FIG. **7** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **1** at decreased pressure and temperature relative to that of FIG. **1**.

FIG. **8** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **1** and an increased HMF feed concentration relative to that of FIG. **1**.

FIG. **9** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **1** at an increased HMF feed concentration and decreased pressure relative to that of FIG. **1**.

FIG. **10** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **1** at an increased HMF feed concentration and a decreased pressure with increased temperature relative to that of FIG. **1**.

FIG. **11** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **1** at an increased temperature relative to FIG. **1**.

FIG. **12** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **1** at an increased pressure relative to that of FIG. **1**.

FIG. **13** shows HMF conversion and product selectivity as a function of temperature utilizing the catalyst of FIG. **1**.

FIG. **14** shows HMF conversion and product selectivity as a function of pressure utilizing the catalyst of FIG. **1**.

FIG. **15** shows HMF conversion and product selectivity as a function of time on stream utilizing an 0.8% palladium supported on carbon catalyst in a continuous flow reactor utilizing a base set of reaction parameters in accordance with one aspect of the invention.

FIG. **16** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **15** at a decreased LHSV relative to FIG. **15**.

FIG. **17** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **15** at an increased temperature and decreased LHSV relative to FIG. **15**.

FIG. **18** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **15** at an increased pressure and decreased LHSV relative to FIG. **15**.

FIG. **19** shows HMF conversion and product selectivity as a function of time on stream utilizing the catalyst of FIG. **15** at reduced pressure and increased temperature and decreased LHSV relative to FIG. **15**.