fuel. Here, the preferred process is methane steam reforming (MSR): $CH_4 + H_2O \rightleftharpoons CO + 3\ H_2$. Again, the gas stream produced by MSR is typically treated by WGSR to increase the hydrogen content. However, rather than being converted to valuable chemicals, the CO from MSR is instead converted to CO_2 which is then released to the atmosphere.

The present invention provides solutions to these and related problems.

SUMMARY

Among other things, the present disclosure encompasses the applicant's recognition that epoxide carbonylation can be performed industrially utilizing syngas streams containing hydrogen, carbon monoxide and varying amounts carbon dioxide. Contrary to expectation, the epoxide carbonylation reaction proceeds selectively in the presence of these mixed gas streams and incorporates excess CO from the syngas stream into valuable chemical precursors. Where the goal of biomass gasification is to maximize the amount of biomass-derived carbon converted to valuable chemical products, the present disclosure has the advantage of incorporating the CO present in syngas into those products. This is economically and environmentally preferable to performing WSGR which converts that CO to CO_2, which is then lost to the atmosphere. The integrated processes herein therefore provide improved carbon efficiency for processes based on coal or biomass gasification or steam methane reforming.

The present disclosure provides an integrated process for the conversion of biomass or coal to FT products and commodity chemicals derived from epoxide carbonylation.

In one aspect of the present disclosure, there is provided a method for the integrated production of chemicals comprising the steps of:

a) in a first reaction zone, contacting an epoxide in the presence of a carbonylation catalyst with a syngas stream containing hydrogen and carbon monoxide thereby causing carbon monoxide in the industrial gas stream to react with the epoxide to provide an epoxide carbonylation product,

b) removing an upgraded gas stream from the first reaction zone wherein the upgraded gas stream has a higher hydrogen to carbon monoxide than the starting syngas stream,

c) in a second reaction zone, utilizing the upgraded gas stream to conduct a second chemical process requiring a hydrogen to CO ratio higher than the ratio in the industrial gas stream utilized in step (a).

In certain embodiments, such methods comprise the steps of:

a) in a first reaction zone, contacting syngas derived from gasification of biomass or coal with an epoxide in the presence of a carbonylation catalyst thereby consuming carbon monoxide from the syngas and producing an epoxide carbonylation product,

b) recovering an upgraded gas stream from the first reaction zone wherein the upgraded gas stream has a higher hydrogen to carbon monoxide ratio than the starting syngas stream,

c) in a second reaction zone, utilizing the upgraded gas stream to conduct a second chemical process requiring a hydrogen to carbon monoxide ratio higher than the ratio in the industrial gas stream utilized in step (a).

In certain embodiments of the method above, the second chemical process comprises the utilization of the syngas with a H_2:CO ratio of ~2 in a Fischer Tropsch synthesis.

The present disclosure also provides an integrated process for the production of hydrogen and commodity chemicals derived from epoxide carbonylation. In certain embodiments, such methods comprise the steps of:

a) in a first reaction zone, contacting a syngas stream derived from biomass or MSW gasification, or a steam reforming process, with an epoxide in the presence of a carbonylation catalyst thereby consuming carbon monoxide from the syngas stream and producing an epoxide carbonylation product,
b) recovering an upgraded gas stream from the first reaction zone wherein the upgraded gas stream has a higher hydrogen to carbon monoxide ratio than the starting syngas stream, and
c) in a second reaction zone, utilizing the upgraded gas stream to conduct a second chemical process requiring a hydrogen to carbon monoxide ratio higher than the ratio in the industrial gas stream utilized in step (a).

In certain embodiments, the epoxide carbonylation product produced in step (a) of the methods above is selected from the group consisting of: optionally substituted beta propiolactone, optionally substituted succinic anhydride, and optionally substituted polypropiolactone. In certain embodiments, the epoxide in the methods above is ethylene oxide and the epoxide carbonylation product is selected from the group consisting of: beta propiolactone, succinic anhydride and polypropiolactone. In certain embodiments, the epoxide in the methods above is propylene oxide and the epoxide carbonylation product is

selected from the group consisting of: beta butyrolactone, methyl succinic anhydride and poly(3-hydroxy butyrate).

In certain embodiments of the methods above, the syngas stream in step (a) is characterized in that it has an H_2 to CO ratio less than 1.2. In certain embodiments, the upgraded gas stream in step (b) is characterized in that it has an H_2 to CO ratio greater than 1.9.

The present disclosure further provides an integrated process for the production of hydrogen and commodity chemicals derived from beta lactone carbonylation. In certain embodiments, such methods comprise the steps of:

a) in a first reaction zone, contacting syngas with a beta propiolactone in the presence of a carbonylation catalyst thereby consuming carbon monoxide from the syngas and producing a succinic anhydride product,
b) recovering an upgraded gas stream from the first reaction zone wherein the upgraded gas stream has a higher hydrogen to carbon monoxide ratio than the starting syngas stream,
c) in a second reaction zone, utilizing the upgraded gas stream to conduct a second chemical process requiring a hydrogen to carbon monoxide ratio higher than the ratio in the industrial gas stream utilized in step (a).

In certain embodiments, the syngas in step (a) is derived from methane steam reforming (MSR). In certain embodiments, the syngas in step (a) is an upgraded gas stream produced as described herein.

In certain embodiments, the beta propiolactone carbonylation reaction zone is operated under conditions such that substantially all of the CO in the syngas stream is consumed.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a schematic of an integrated process according to the present invention,