

to the depletion of accessible fossil fuel supplies and is also expected to rise as the depletion of world crude oil reserves continues.

There is a need for alternative methods to produce hydrocarbon products such as gasoline and lower olefins that place less reliance on utilizing the depleting world reserves of crude oil. In particular, a need exists for alternative methods for producing hydrocarbon products from renewable sources. Preferably, the alternative methods have reduced adverse effects on the environment and/or provide hydrocarbon products of comparable or increased quality compared to methods utilising crude oil. Preferably, the alternative methods provide hydrocarbon products for reduced economic cost.

SUMMARY OF THE INVENTION

The present ~~disclosureinvention~~ provides methods for producing hydrocarbon products such as gasoline and lower olefins from renewable sources. The methods of the present ~~disclosureinvention~~ may have reduced adverse environment effects and/or economic cost compared to existing technologies relying on the extraction and use of crude oil. Additionally or alternatively, hydrocarbon products produced by the methods of the present ~~disclosureinvention~~ may be of comparable or increased quality to those produced from crude oil and other similar feedstocks.

In one aspect, ~~there is invention~~ provides a method for producing a hydrocarbon product from coal comprising the following steps:

converting the coal to a coal-oil by thermal or hydrothermal conversion;
optionally-processing the coal-oil in a hydroprocessing reaction to remove one or more of oxygen, nitrogen or sulfur from hydrocarbon compounds in the coal-oil; and using at least a portion of the coal-oil as a feedstock in a cracking reaction to convert hydrocarbon compounds in the feedstock into a mixture of smaller hydrocarbon compounds comprising the hydrocarbon product.

In another aspect, ~~there is invention~~ provides a method for producing a hydrocarbon product from biomass comprising the following steps:

converting the biomass to bio-oil by thermal or hydrothermal conversion;
optionally-processing the bio-oil in a hydroprocessing reaction to remove one or more of oxygen, nitrogen or sulfur from hydrocarbon compounds in the bio-oil; and using at least a portion of the bio-oil as a feedstock in a cracking reaction to convert hydrocarbon compounds in the feedstock into a mixture of smaller hydrocarbon compounds comprising the hydrocarbon product.

In another ~~embodiment~~ ~~aspect~~, the ~~disclosure~~ ~~invention~~ provides a method for producing a hydrocarbon product from a bio-oil, coal-oil, or mixture thereof, the method comprising:

optionally processing the bio-oil, coal-oil, or mixture thereof in a hydroprocessing reaction to remove one or more of oxygen, nitrogen or sulfur from hydrocarbon compounds in the bio-oil; and

using at least a portion of the bio-oil, coal-oil, or mixture thereof as a feedstock in a cracking reaction to convert hydrocarbon compounds in the feedstock into a mixture of smaller hydrocarbon compounds comprising the hydrocarbon product.

In one embodiment, the feedstock is comprised of at least 50% of the bio-oil and the hydrocarbon product is at least a 50% renewable product.

In another embodiment, the feedstock is comprised of at least 75% of the bio-oil and the hydrocarbon product is at least a 75% renewable product.

In one embodiment, the feedstock is comprised of at least 90% of the bio-oil and the hydrocarbon product is at least a 90% renewable product.

In one embodiment, the feedstock is comprised of at least 95% of the bio-oil and the hydrocarbon product is at least a 95% renewable product.

In one embodiment, the feedstock is comprised of at least 98% of the bio-oil and the hydrocarbon product is at least a 98% renewable product.

In one embodiment, the feedstock is 100% bio-oil and the hydrocarbon product is a 100% renewable product.

In one embodiment, the converting is by fast pyrolysis reaction.

In one embodiment, the hydroprocessing reaction includes a hydrodeoxygenation reaction.

In a particular embodiment the cracking reaction is a catalytic cracking reaction utilizing a powdered catalyst at a reaction temperature of between about 500°C and 600°C, and a reaction pressure of between about 1400 KPa and 2000 KPa.

In a further embodiment the cracking reaction is a catalytic cracking reaction utilized to convert hydrocarbons of C₁₂ or above into a hydrocarbon product selected from any one or more of gasoline and fuel oil.

In a further embodiment the method comprises the step of processing the oil in a hydroprocessing reaction, wherein the hydroprocessing reaction additionally produces a hydrocarbon product selected from any one or more of a gasoline, lower olefins, and naphtha. Preferably the gasoline is of a high quality with a high octane number.

In another embodiment the step of processing the oil in a hydroprocessing reaction is omitted.

In another embodiment the hydroprocessing reaction is performed in a multi-bed hydroprocessing plant or a series flow hydroprocessing plant.

In a further embodiment the hydroprocessing plant is integrated with a methanol plant, hydrogen produced from methanol plant is fed to the hydroprocessing plant for use in the catalytic hydroprocessing reaction, and C₁ to C₄ hydrocarbons produced from the hydroprocessing reaction are used as a feedstock for the methanol plant.

In another ~~embodiment~~ aspect, the ~~disclosure~~ invention provides a hydrocarbon product produced by a method of the ~~disclosure~~ invention.

Other aspects, features and advantages of this ~~disclosure~~ invention will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, which are a part of this disclosure and which illustrate, by way of example, principles of this ~~disclosure~~ invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The following figures are used to illustrate the preferred embodiments of the invention and in no way are to be considered limiting.

Figure 1 shows a schematic of a single stage hydroprocessing plant according to an embodiment of the invention.

Figure 2 shows a schematic of a series flow oil hydroprocessing plant according to an embodiment of the invention.

Figure 3 shows a schematic of a two-stage hydroprocessing plant according to an embodiment of the invention.

Figure 4 shows a schematic of a methanol plant integrated with a hydroprocessing plant according to an embodiment of the invention.

Figure 5 shows a schematic of a steam reformer process for producing lower olefins and gasoline from naphtha according to an embodiment of the invention.

Figure 6 shows a schematic of a catalytic cracker according to an embodiment of the invention.

Figures 7a and 7b show flow charts representative of processes according to embodiments of the invention.

Figure 8a and 8b show flow charts representative of processes according to embodiments of the invention.

Figure 9 shows a schematic of a Micro Activity Test (MAT) unit comprising a fixed bed of catalyst contained in a Pyrex glass reactor supported in a temperature controlled furnace.