PROPYLENE PRODUCTION PROCESS

Processes and systems for forming propylene are described herein. The processes generally include reacting a metathesis feed stream including at least 95 wt. % 2-butene with ethylene in the presence of a metathesis catalyst to form a metathesis product stream including propylene, and recovering propylene from the process.
PROPYLENE PRODUCTION PROCESS
CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of and priority of U.S. Provisional Application No. 61/762,427 filed on Feb. 8, 2013, and is a continuation-in-part of and claims benefit of U.S. Non-Provisional application Ser. No. 12/903,794 filed on Oct. 13, 2010, all of which are incorporated herein by reference in their entirety.

BACKGROUND

[0002] 1. Field of the Invention
[0003] The present invention generally relates to methods and systems of forming propylene.
[0004] 2. Related Art
[0005] This section introduces information from the art that may be related to or provide context for some aspects of the technique described herein and/or claimed below. This information is background facilitating a better understanding of that which is disclosed herein. This is a discussion of “related” art. That such art is related in no way implies that it is also “prior” art. The related art may or may not be prior art. The discussion is to be read in this light, and not as admissions of prior art.
[0006] Metathesis reactions to produce propylene generally include feeding a metathesis feed stream comprising butene, generally a mixture of 1-butene and 2-butene, to a metathesis reactor loaded with a mixture of metathesis catalyst and an isomerization catalyst. Such process provide for efficiencies by utilizing a single process for the production of propylene from available feedstocks. However, reaction of 1-butene can cause side reactions, forming undesirable by-products, such as pentene and hexene, for example.
[0007] The present invention is directed to resolving, or at least reducing, one or all of the problems mentioned above.

SUMMARY

[0008] Various embodiments of the present invention include processes of forming propylene. The processes generally include separating a butene feed stream in a butene fractionation system that, in operation, separates 1-butene from 2-butene; recovering 2-butene from the butene fractionation system and utilizing the 2-butene to form a metathesis feed stream including at least 95 wt. % 2-butene; reacting the metathesis feed stream with ethylene in the presence of a metathesis catalyst to form a metathesis product stream including propylene; and recovering propylene from the process.
[0009] One or more embodiments include the process of the preceding paragraph, wherein the metathesis feed stream reacts with the ethylene in the absence of an amount of isomerization catalyst sufficient to isomerize butene.
[0010] One or more embodiments include the process of the preceding paragraph, wherein the metathesis feed stream reacts with the ethylene in the absence of an isomerization catalyst.
[0011] One or more embodiments include the process of the preceding paragraph, wherein the metathesis feed stream is formed essentially of 2-butene.
[0012] One or more embodiments include the process of any preceding paragraph, wherein the metathesis feed stream includes at least 98 wt. % 2-butene.

[0013] One or more embodiments include the process of any preceding paragraph, wherein the metathesis feed stream includes a molar ratio of 2-butene:1-butene of at least 49:1.
[0014] One or more embodiments include the process of any preceding paragraph, wherein the metathesis feed stream includes less than 5 wt. % 1-butene.
[0015] One or more embodiments include the process of any preceding paragraph further including contacting a first feed stream including ethylene with a dimerization catalyst to form a dimerization product stream including 2-butene, wherein the butene feed stream includes the dimerization product stream.
[0016] One or more embodiments include the process of any preceding paragraph, wherein the dimerization catalyst is selected from metal oxides, nickel complexes, aluminum complexes and combinations thereof.
[0017] One or more embodiments include the process of any preceding paragraph, wherein the metathesis catalyst includes a transition metal oxide.
[0018] One or more embodiments include the process of any preceding paragraph, wherein the metathesis catalyst includes tungsten oxide.
[0019] One or more embodiments include the process of any preceding paragraph, wherein the metathesis product stream includes less than 1 mol. % pentene.
[0020] One or more embodiments include the process of any preceding paragraph, wherein the metathesis product stream further includes C2 to C6 olefins and wherein recovering the propylene includes fractionating within a propylene fractionation system the metathesis product stream to form a propylene steam, a recycle stream including olefins selected from butene, ethylene and combinations thereof, and optionally a bottoms stream including olefins selected from C5 olefins, C6+ olefins and combinations thereof.
[0021] One or more embodiments include the process of the preceding paragraph further including passing the recycle stream from the propylene fractionation system to the metathesis reaction without passing the recycle stream through an isomerization reaction.
[0022] One or more embodiments include the process of the preceding paragraph, wherein the propylene fractionation system includes a first stage that, in operation, separates ethylene from other components present in the metathesis product stream to form a de-ethenized product stream; and a second stage that, in operation, separates propylene from C4 and heavier olefins in the de-ethenized product stream.
[0023] One or more embodiments include the process of any preceding paragraph, wherein the process produces at least 100 MM lbs/yr of propylene.
[0024] One or more embodiments include the process of any preceding paragraph, wherein the metathesis reaction exhibits a propylene selectivity of at least 95%, wherein “propylene selectivity” is defined as the propylene production divided by the propylene plus C4 and heavier olefins produced in the metathesis reaction, expressed as a percentage.
[0025] One or more embodiments include a process for forming propylene including contacting a first feed stream including ethylene with a dimerization catalyst to form a dimerization product stream; fractionating the dimerization product stream to form a 2-butene stream; reacting the 2-butene stream with ethylene in the presence of a metathesis catalyst to form a metathesis product stream including propylene, wherein the 2-butene stream reacts with the ethylene in the absence of an amount of isomerization catalyst suffi-
cient to isomerize butene; and recovering propylene from the process, wherein the process produces at least 100 MM lbs/yr of propylene.

[0026] The above paragraphs present a simplified summary of the presently disclosed subject matter in order to provide a basic understanding of some aspects thereof. The summary is not an exhaustive overview, nor is it intended to identify key or critical elements to delineate the scope of the subject matter claimed below. Its sole purpose is to present some concepts in a simplified form as a prelude to the more detailed description set forth below.

BRIEF DESCRIPTION OF DRAWINGS

[0027] The claimed subject matter may be understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like elements, and in which:

[0028] FIG. 1 illustrates a simplified process flow diagram for various embodiments described herein.

[0029] FIG. 2 illustrates a specific embodiment of a propylene production process.

[0030] FIG. 3 illustrates an alternative embodiment of a propylene production process.

[0031] While the invention is susceptible to various modifications and alternative forms, the drawings illustrate specific embodiments herein described in detail by way of example. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION

[0032] Illustrative embodiments of the subject matter claimed below will now be disclosed. In the interest of clarity, not all features of an actual implementation are described in this specification. It will be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers’ specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort, even if complex and time-consuming, would be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0033] In the description below, unless otherwise specified, all compounds described herein may be substituted or unsubstituted and the listing of compounds includes derivatives thereof. Further, various ranges and/or numerical limitations may be expressly stated below. It should be recognized that unless stated otherwise, it is intended that endpoints are to be interchangeable. Further, any ranges include iterative ranges of like magnitude falling within the expressly stated ranges or limitations.

[0034] Processes for forming propylene are described herein. The processes generally include reacting a metathesis feed stream including 2-butene with ethylene in the presence of a metathesis catalyst to form a metathesis product stream including propylene.

[0035] In one or more specific embodiments, the metathesis feed stream may be formed by contacting a first feed stream including ethylene with a dimerization catalyst to form a dimerization product stream including 2-butene. As used herein, the term “dimerization” refers to a chemical reaction in which two identical molecular entities react to form a single dimer. In the present embodiments, the identical molecular entities are generally ethylene, while the dimer is generally butene.

[0036] The dimerization catalyst may include catalyst known in the art to be capable of converting ethylene to linear C₂ olefins (i.e., n-butene) upon reaction. For example, dimerization catalysts may include homogenous catalyst compounds including nickel. Many catalysts containing nickel are known to dimerize ethylene to butenes (e.g., U.S. Letters Pat. No. 4,528,415, U.S. Letters Pat. No. 3,513,218 and U.S. Letters Pat. No. 3,452,115).

[0037] Alternatively, the dimerization catalyst may include an organoaluminum compound of the formula R₃AlX₃-n, wherein R is selected from alkenes, such as butyl, ethyl and methyl, X is selected from halogens, such as chlorine and n is 0, 1 or 2, for example.

[0038] Although the dimerization may be carried out in any reactor type, such as a loop reactor, for example. The dimerization may be carried out under moderate conditions, such as temperatures of from 20°C to 400°C, or from 25°C to 150°C, or from 30°C to 55°C, and pressures of from 200 psi to 400 psi, or from 250 psi to 350 psi or from 265 psi to 315 psi, for example.

[0039] Depending on the embodiment, the dimerization product stream and/or an isomerization product stream generally include n-butenes, including 1-butene and 2-butene. The processes described herein includes emhdmbtions wherein the metathesis feed stream includes primarily 2-butene. For example, in one or more embodiments, the metathesis feed stream includes less than 5 wt. %, or less than 4 wt. %, or less than 3 wt. %, or less than 2 wt. % or less than 1 wt. % 1-butene. Accordingly, the metathesis feed stream may include at least 95 wt. %, or at least 97 wt. %, or at least 98 wt. % or at least 99 wt. % 2-butene, for example. Alternatively, the metathesis feed stream may include a molar ratio of 2-butene:1-butene of at least 20:1, or at least 49:1, or at least 100:1, for example.

[0040] One or more embodiments include separating the dimerization product stream via a separation process. The separation process may include those known in the art, such as fractionation. As used herein, the term “fractionation” refers to processes for the separation of components based on the relative volatility and/or boiling point of the components. The fractionation processes may include those known in the art and the term “fractionation” can be used interchangeably with the terms “distillation” and “fractional distillation” herein.

[0041] In one or more specific embodiments, the dimerization product stream may be separated in a butene fractionation system. The butene fractionation system may include a first section and a second section. The first section may include a column or columns adapted to separate butene from other components present in the isomerization product stream, such as unreacted ethylene and trimers and heavier oligomers of ethylene, for example. The second section may include a column adapted to separate 1-butene from 2-butene.

[0042] The 2-butene is generally recovered from the separation process and passed to the metathesis feed stream. In one or more embodiments, 1-butene is recovered from the separation process utilized as a high value feed stream for other chemical processes.
[0043] Embodiments described herein include reacting the metathesis feed stream with ethylene in the presence of a metathesis catalyst to form a metathesis product stream (i.e., a metathesis reaction). As used herein, the term “metathesis” refers to an equilibrium reaction between two olefins where the double bond of each olefin is broken to form intermediate reactants. These intermediates recombine to form new olefin products. In the specific embodiments discussed herein, the two olefins include ethylene and butene and the new olefin product is propylene.

[0044] As discussed previously herein, the butene, preferably 2-butene, is fed to the metathesis reaction via the metathesis feed stream. The ethylene may be fed to the reactor by methods known to one skilled in the art. For example, the ethylene may be fed to the metathesis reaction via an inlet separate from an inlet utilized to feed the metathesis feed stream. Alternatively, the ethylene may be combined with the metathesis feed stream prior to the metathesis feed stream passing through said inlet. However, regardless of what method is utilized to pass the ethylene to the metathesis reaction, all references referring to the amount/concentration of 2-butene or 1-butene in the metathesis feed stream refer to such prior to contact/mixing with ethylene.

[0045] The molar ratio of ethylene to butene contacting the metathesis catalyst may range from 0.1:1 to 2.5:1, or from 0.8:1 to 2:1 or from 1.5:1 to 2:1, for example.

[0046] The metathesis reaction includes contacting the butene with ethylene in the presence of a metathesis catalyst. Metathesis catalysts are well known in the art (see, e.g., U.S. Letters Pat. No. 4,513,069 and U.S. Letters Pat. No. 5,120,894). Generally, the metathesis catalyst includes a transition metal oxide, such as transition metal oxides of cobalt, molybdenum, rhenium, tungsten, ruthenium, and combinations thereof, for example. In one or more specific embodiments, the metathesis catalyst includes tungsten oxide. The metathesis catalyst may be supported on a carrier, such as silica, alumina, titania, zirconia, zeolites, clays and mixtures thereof, for example. In one or more embodiments, the carrier is selected from silica, alumina and combinations thereof. The catalyst may be supported on a carrier by methods known in the art, such as adsorption, ion-exchange, impregnation or sublimation, for example. The metathesis catalyst may include from 1 wt. % to 30 wt. % or from 5 wt. % to 20 wt. % transition metal oxide, for example.

[0047] Historically, the metathesis reaction also included contacting the butene with ethylene in the presence of an isomerization catalyst. The isomerization catalyst was adapted to convert 1-butene present in the metathesis feed stream to 2-butene for subsequent reaction to propylene, thereby improving the reaction yield of propylene (e.g., conversion rates of from 65% to 70% and selectivity rates of from 90% to 98%). However, such contact with the isomerization catalyst often resulted in the formation of more undesirable by-products such as pentene and hexene, for example.

[0048] Some embodiments of this invention utilize isomerization catalysts to catalyze the conversion of 1-butene to 2-butene. Isomerization catalysts may include zeolites, metal oxides, mixed metal oxides and combinations thereof, for example. In one or more embodiments, the isomerization catalyst includes a basic double-bond isomerization catalyst, such as a metal oxide (e.g., magnesium oxide, tungsten oxide, calcium oxide, barium oxide, lithium oxide and combinations thereof). Metal oxides supported on a carrier may be used. Suitable carriers include silica, alumina, titania, silica-alumina and combinations thereof for example.

[0049] Isomerization catalysts capable of converting 1-butene to 2-butene may generally include metal oxides (e.g., alumina, zirconia, sulfated zirconia), mixed oxides (e.g., silica-alumina, zirconia-silica), acidic zeolites, acidic clays (see, e.g., U.S. Letters Pat. No. 5,153,165; U.S. Letters Pat. No. 4,992,613; U.S. Patent Publication 2004/0249229 and U.S. Patent Publication 2006/0084831). In one or more specific embodiments, the catalyst is magnesium oxide. The magnesium oxide may have a surface area of at least 1 m²/g or at least 5 m²/g, for example.

[0050] Various embodiments of the present invention are capable of forming propylene at high selectivity/productivity without the use of the isomerization catalyst. In fact, some embodiments include reaction of the metathesis feed stream and the ethylene in the absence of an isomerization catalyst. The embodiments described herein are capable of forming a metathesis product stream including less that 2 mol. % or less than 1.5 mol. %, or less than 1 mol. % or less than 0.5 mol. % pentene, for example.

[0051] The metathesis reactions generally occur at more severe reaction conditions than the dimerization and/or isomerization reaction. For example, the metathesis reaction may occur at a pressure of from 150 psig to 600 psig, or from 200 psig to 500 psig, for example. The metathesis reaction may occur at a temperature of from 100° C. to 500° C., or from 200° C. to 400° C. or from 300° C. to 350° C., for example. The metathesis reaction may occur at a WHSV of from 3 hr⁻¹ to 200 hr⁻¹ or from 25 hr⁻¹ to 40 hr⁻¹, for example. In one or more embodiments, the propylene production process produces at least 100 MM lbs/year, or at least 300 MM lbs/year, or at least 500 MM lbs/year or at least 800 MM lbs/year of propylene, for example.

[0052] The contact time needed to obtain a desirable yield of metathesis reaction products depends upon several factors, such as the activity of the catalyst, temperature and pressure, for example. However, in one or more embodiments, the length of time during which the metathesis feed stream and the ethylene are contacted with the catalyst can vary from 0.1 to 4 hours or from 0.5 to 5 hours, for example. The metathesis reaction may be conducted batch-wise or continuously with fixed catalyst beds, slurred catalyst, fluidized beds, or by using any other conventional contacting techniques, for example.

[0053] One or more embodiments include utilizing the isomerization catalyst that historically had been utilized in the metathesis reaction as an isomerization catalyst for use in the propylene or butene fractionation systems, for example. Such processes provide for the utilization of more ideal conditions (i.e., temperature and pressure) for the isomerization catalyst than possible when utilized in the metathesis reaction.

[0054] The metathesis product stream generally includes ethylene, propylene, C₄ olefins, C₅ olefins and C₆+ olefins. Therefore, the process may further include separating the metathesis product stream into an ethylene stream, a propylene product stream, a C₄ stream and a C₅+ olefins stream. Such separation is known in the art (see, U.S. Letters Pat. No. 7,214,841). In one or more specific embodiments, the metathesis product stream is separated within a propylene fractionation system. The propylene fractionation system generally separates the metathesis product stream into a propylene
stream, one or more recycle streams and a bottoms stream. The bottoms stream may include the C₅ and C₆₀ olefins, for example.

[0055] The recycle stream(s) may include olefins selected from butene, ethylene and combinations thereof, for example. In one or more embodiments, the recycle stream(s) may pass from the propylene fractionation system to the metathesis reaction downstream of any dimerization reaction, to the extent a dimerization reaction takes place, and without contacting isomerization catalyst.

[0056] In one or more specific embodiments, the propylene fractionation system may include a first stage and a second stage. The first stage is generally adapted to separate ethylene from other components present in the metathesis stream. The second stage is generally adapted to separate propylene from

C₅ and heavier olefins, for example.

[0057] The recycle stream(s) may include olefins selected from butene, ethylene and combinations thereof, for example. In one or more embodiments, the recycle stream (or streams) may pass from the propylene fractionation system to the metathesis reaction without passing through a dimerization reactor or isomerization reactor. While described as “a recycle stream” exiting the propylene fractionation system, it is contemplated that the recycle stream may include multiple recycle streams. For example, when utilizing the first stage and the second stage, there may be a first recycle stream exiting the first stage that includes ethylene, while there may be a second recycle stream exiting the second stage that includes unreacted butene. It is further contemplated that in one or more embodiments, the “recycle stream” may not be recycled back to the propylene production process at all, but utilized in other chemical processes, for example.

[0058] Referring now to FIG. 1, a simplified process flow diagram of a process 100 for producing propylene according to embodiments disclosed herein is illustrated. FIG. 1 illustrates a process 100 including introducing a metathesis feed stream 102A to a metathesis reactor 104 having metathesis catalyst 105 disposed therein to form metathesis product stream 106. FIG. 1 illustrates a specific embodiment wherein ethylene 121 is mixed with the metathesis feed stream 102 via line 108 to form metathesis feed stream 102A.

[0059] In the embodiment illustrated in FIG. 1, a first feed stream 110 is introduced as a dimerization reactor 112 having dimerization catalyst 115 disposed therein to form dimerization product stream 114. The dimerization product stream 114 (or a portion thereof) is generally utilized as the metathesis feed stream 102. However, this is not necessary for the practice of the invention and may vary in alternative embodiments as the feed stream 102 may be obtained in other ways in other embodiments.

[0060] A specific embodiment is illustrated in FIG. 2 wherein the embodiment includes the dimerization reactor 112 and the metathesis reactor 104. However, FIG. 2 illustrates a process 200 wherein the dimerization product stream 114 is passed to a butene fractionation system 116. The butene fractionation system 116 includes a first column 118 adapted to separate butene present in the dimerization product stream 114 from other components to form a stream 122 including butene and a first column bottoms stream 122. Those in the art having the benefit of this disclosure will recognize that there are a number of suitable separation techniques well known to the art that may be used to achieve this separation. Any such suitable technique may be used. The stream 120 is passed to a second column 124 adapted to separate 1-butene from 2-butene, forming a stream 128 including 2-butene and a stream 126 including 1-butene.

[0061] The stream 128 feeds into the metathesis feed stream 102A which includes stream 128, ethylene 121 (via line 108), optionally stream 134 discussed in detail below, and optionally stream 142, also discussed in detail below. The metathesis feed stream 102A undergoes reaction within the metathesis reactor 104, which contains metathesis catalyst 105, to form the metathesis product stream 106. It is significant to note that process 200 includes reaction within the metathesis reactor 104 in the absence of isomerization catalyst. In the specific embodiment illustrated in FIG. 2, the metathesis product stream 106 is passed to a propylene fractionation system 130.

[0062] The propylene fractionation system 130 includes a first stage 132 adapted to separate ethylene from other components present in the metathesis product stream 106, thereby forming a stream 134 including ethylene and a first stage bottoms stream 136. The first stage bottoms stream 136 is generally passed to a second stage 138 adapted to separate propylene from C₅ and heavier olefins. The propylene is recovered via stream 140, the C₅ olefins are recovered via stream 142. The ethylene stream 134 may be recycled back to the metathesis feed stream 102A or directly to the metathesis reactor 104, while the C₅ olefins in stream 142 may be recycled back to the second column 124 via line 143, directly to the metathesis reactor 104 or to the metathesis feed stream 102A as shown. While the second stage 138 is adapted to separate propylene, C₄ olefins and C₅+ olefins (heavier olefins), FIG. 2 does not illustrate the removal of the C₅+ olefins from the second stage 138 or stream 142. Separation and removal of heavier olefins is known in the art and may occur within the second stage 138 via a separate stream or may include further separation of stream 142 to remove the heavier olefins therefrom. Such separation could be achieved by recycling all or a portion of stream 142 to the butene fractionation system 118, for example.

[0063] Another specific embodiment is illustrated in FIG. 3 wherein the embodiment includes the dimerization reactor 112 and the metathesis reactor 104. However, FIG. 3 illustrates a process 300 wherein the dimerization product stream 114 is passed to a catalyst quench system 302. The catalyst quench system 302 cools the effluent in the dimerization product stream 114 and provides the ability to recover dimerization catalyst 115 present in the dimerization product stream 114. The product from the catalyst quench system passes via line 304 to a butene recovery tower 306, which is adapted to separate butene present in the dimerization product stream 114 from other components to form a stream 308 including butene and a bottoms stream 310. The bottoms stream 310 generally includes heavy components capable for use in gasoline, for example. Those in the art having the benefit of this disclosure will recognize that there are a number of suitable separation techniques well known to the art that may be used to achieve the butene recovery. Any such suitable technique may be used. The stream 308 is passed to a butene dryer 312 to form stream 314, which is subsequently passed to a butene splitter 316 adapted to separate 1-butene from 2-butene, forming a stream 318 including 2-butene and a stream 320 including 1-butene.

[0064] The stream 318 feeds into the metathesis feed stream 102A which includes ethylene 121 (via line 108). The metathesis feed stream 102A undergoes reaction within the metathesis reactor 104, which contains metathesis catalyst
to form the metathesis product stream 106. It is significant to note that process 300 includes reaction within the metathesis reactor 104 in the absence of an amount of isomerization catalyst sufficient to isomerize butene. In the specific embodiment illustrated in FIG. 3, the metathesis product stream 106 is passed to a de-ethenizer 322 adapted to separate ethylene from other components present in the metathesis product stream 106, thereby forming a stream 328 including ethylene and a bottoms stream 324. The bottoms stream 324 is generally passed to a de-propenizer 326 adapted to separate propylene from C4 and heavier olefins. The propylene is recovered via stream 330 and the C4 olefins are recovered via stream 332.

[0065] The ethylene stream 328 may be recycled back to the metathesis feed stream 102A or optionally passed through a feed conditioning system 325 to form conditioned ethylene in line 336, which passes to feed stream 102A. The C4 olefins in stream 332 may be recycled back to the metathesis reactor 104. While the de-propenizer 326 is adapted to separate propylene, C4 olefins and C4+ olefins (heavier olefins), FIG. 3 does not illustrate the removal of the C4+ olefins from the de-propenizer 326. Separation and removal of heavier olefins is known in the art and may occur within the de-propenizer 326 via a separate stream or may include further separation of stream 332 to remove the heavier olefins therefrom.

EXAMPLES

[0066] Metathesis reactions were compared by feeding various feedstocks, along with ethylene into a metathesis reactor with either a mixed catalyst system (i.e., MgO+W2O5) or a metathesis catalyst (WO3) in the absence of an isomerization catalyst. The reaction conditions are summarized in Table 1 below.

<table>
<thead>
<tr>
<th>Run #</th>
<th>Catalyst</th>
<th>Feed</th>
<th>WHSV</th>
<th>T (°C)</th>
<th>C4 (mol. %)</th>
<th>C4+C6 (mol. %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comp 1a</td>
<td>MgO + W2O5</td>
<td>B1 + C2</td>
<td>10</td>
<td>500</td>
<td>46.5</td>
<td>5.7</td>
</tr>
<tr>
<td>Comp 1b</td>
<td>MgO + W2O5</td>
<td>B2 + C2</td>
<td>10</td>
<td>500</td>
<td>48.7</td>
<td>6.5</td>
</tr>
<tr>
<td>Example</td>
<td>W2O5</td>
<td>B1 + C2</td>
<td>10</td>
<td>500</td>
<td>54.4</td>
<td>0.99</td>
</tr>
<tr>
<td>Comp 2a</td>
<td>MgO + W2O5</td>
<td>B1 + C2</td>
<td>10</td>
<td>400</td>
<td>45.6</td>
<td>6.2</td>
</tr>
<tr>
<td>Comp 2b</td>
<td>MgO + W2O5</td>
<td>B2 + C2</td>
<td>10</td>
<td>400</td>
<td>49.8</td>
<td>5.2</td>
</tr>
<tr>
<td>Example</td>
<td>W2O5</td>
<td>B2 + C2</td>
<td>10</td>
<td>400</td>
<td>54.6</td>
<td>0.44</td>
</tr>
</tbody>
</table>

*H1 refers to 1-butene, H2 refers to 2-butene, C2 refers to ethylene, C3 refers to formed propylene, WHSV was calculated from reactants B1 or B2 over tungsten catalyst. For mixed catalyst configuration, 7.5 g tungsten catalyst and 30 g magnesium catalyst were used. Example 1 and Example 2 utilized 7.5 g tungsten catalyst alone.

[0067] It was observed that the level of C4+ olefins formed significantly decreased when the isomerization catalyst (MgO) was eliminated from the metathesis reaction. In fact, the amount of C4+ olefins produced was negligible (e.g., less than 1 mol. %).

[0068] Furthermore, when a feed composed primarily of 2-butenes was contacted with a mixed catalyst system (i.e., the metathesis catalyst and the isomerization catalyst), the yield of propylene increased, however, the level of C4+ olefins produced also increased.

[0069] The processes described herein may result in a similar or increased propylene productivity compared to processes utilizing mixed catalyst systems.

[0070] The particular embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

What is claimed is:

1. A process for forming propylene comprising: separating a butene feed stream in a butene fractionation system that, in operation, separates 1-butene from 2-butene; recovering 2-butene from the butene fractionation system and utilizing the 2-butene to form a metathesis feed stream comprising at least 95 wt. % 2-butene; reacting the metathesis feed stream with ethylene in the presence of a metathesis catalyst to form a metathesis product stream comprising the propylene; and recovering the propylene from the process.

2. The process of claim 1, wherein the metathesis feed stream reacts with the ethylene in the absence of an amount of isomerization catalyst sufficient to isomerize butene.

3. The process of claim 1, wherein the metathesis feed stream reacts with the ethylene in the absence of an isomerization catalyst.

4. The process of claim 1, wherein the metathesis feed stream consists essentially of 2-butene.

5. The process of claim 1, wherein the metathesis feed stream comprises at least 98 wt. % 2-butene.

6. The process of claim 1, wherein the metathesis feed stream comprises a molar ratio of 2-butene:1-butene of at least 49:1.

7. The process of claim 1, wherein the metathesis feed stream comprises less than 5 wt. % 1-butene.

8. The process of claim 1 further comprising: contacting a first feed stream comprising ethylene with a dimerization catalyst to form a dimerization product stream comprising 2-butene, wherein the butene feed stream comprises the dimerization product stream.

9. The process of claim 8, wherein the dimerization catalyst is selected from metal oxides, nickel complexes, aluminium complexes and combinations thereof.

10. The process of claim 1, wherein the metathesis catalyst comprises a transition metal oxide.

11. The process of claim 1, wherein the metathesis catalyst comprises tungsten oxide.

12. The process of claim 1, wherein the metathesis product stream comprises less than 1 mol. % pentene.

13. The process of claim 1, wherein the metathesis product stream further comprises C2 to C3 olefins and wherein recovering the propylene comprises fractionating within a propylene fractionation system the metathesis product stream to form a propylene product stream, at least one recycle stream comprising olefins selected from butene, ethylene and combinations thereof, and a bottoms stream comprising olefins selected from C3 olefins, C4 olefins and combinations thereof.

14. The process of claim 13 further comprising passing the recycle stream from the propylene fractionation system to the metathesis reaction without passing through an isomerization reaction.

15. The process of claim 13, wherein the propylene fractionation system comprises:
a first stage that, in operation, separates ethylene from other components present in the metathesis product stream to form a de-ethenized product stream; and a second stage that, in operation, separates propylene from C4 and heavier olefins in the de-ethenized product stream.

16. The process of claim 1, wherein the process produces at least 100 MM lbs/yr of propylene.

17. The process of claim 1, wherein the metathesis reaction exhibits a propylene selectivity of at least 95%.

18. A process for forming propylene comprising:
reacting a first feed stream comprising ethylene with a dimerization catalyst to form a dimerization product stream;
fractionating the dimerization product stream to form a 2-butene stream;
reacting the 2-butene stream with ethylene in the presence of a metathesis catalyst to form a metathesis product stream comprising the propylene, wherein the 2-butene stream reacts with the ethylene in the absence of an amount of isomerization catalyst sufficient to isomerize butene; and
recovering the propylene from the process, wherein the process produces at least 100 MM lbs/yr of the propylene.

19. The process of claim 18, wherein the metathesis reaction exhibits a propylene selectivity of at least 95%.

20. The process of claim 18, wherein the metathesis catalyst comprises a transition metal oxide.

21. The process of claim 18, wherein the metathesis product stream comprises less than 1 mol. % pentene.

22. The process of claim 18, wherein the metathesis feed stream consists essentially of 2-butene.