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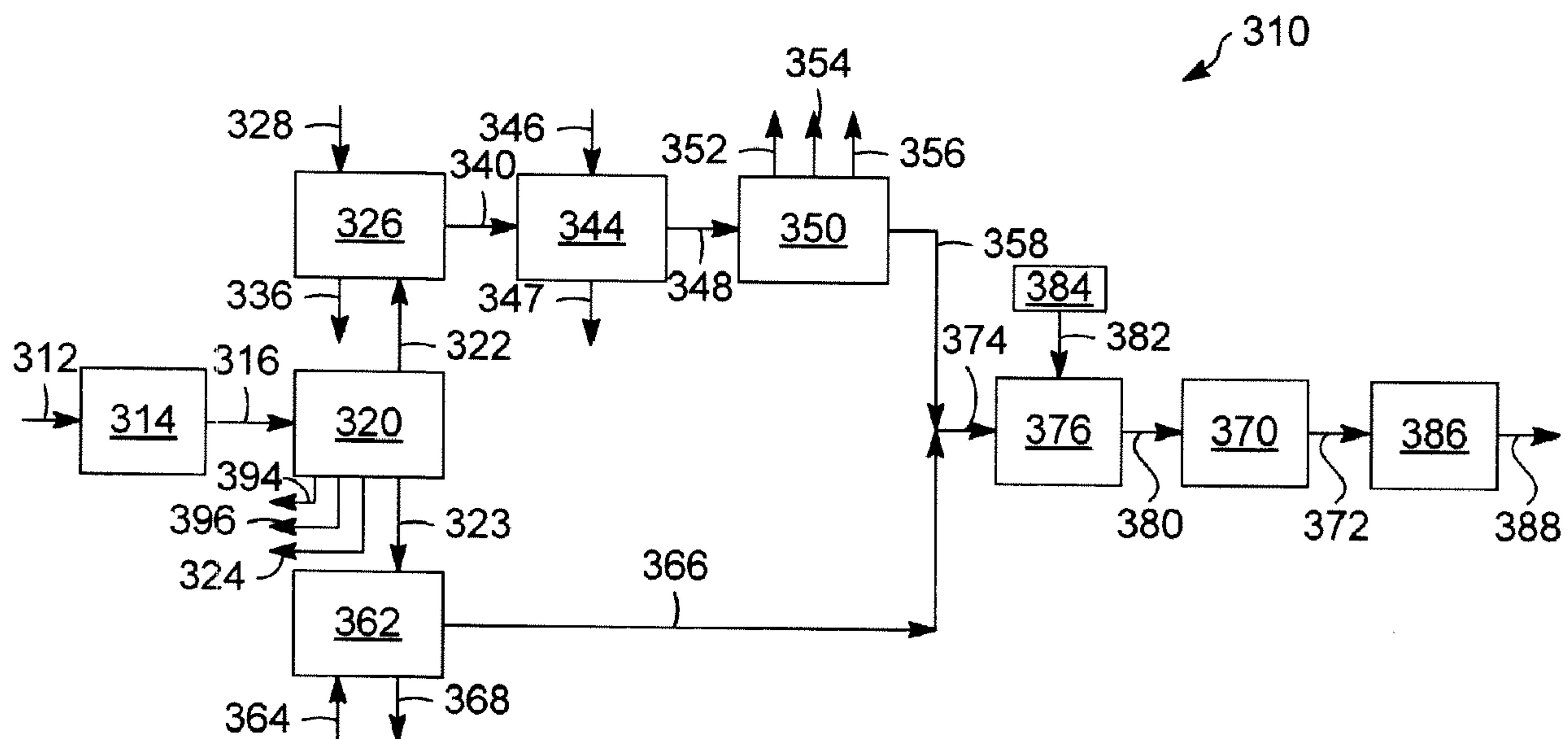
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Water and/or oxygenate content in olefin cracking feeds is/are reduced or minimized to enhance light olefin production via integrated oxygenate conversion and product olefin cracking.

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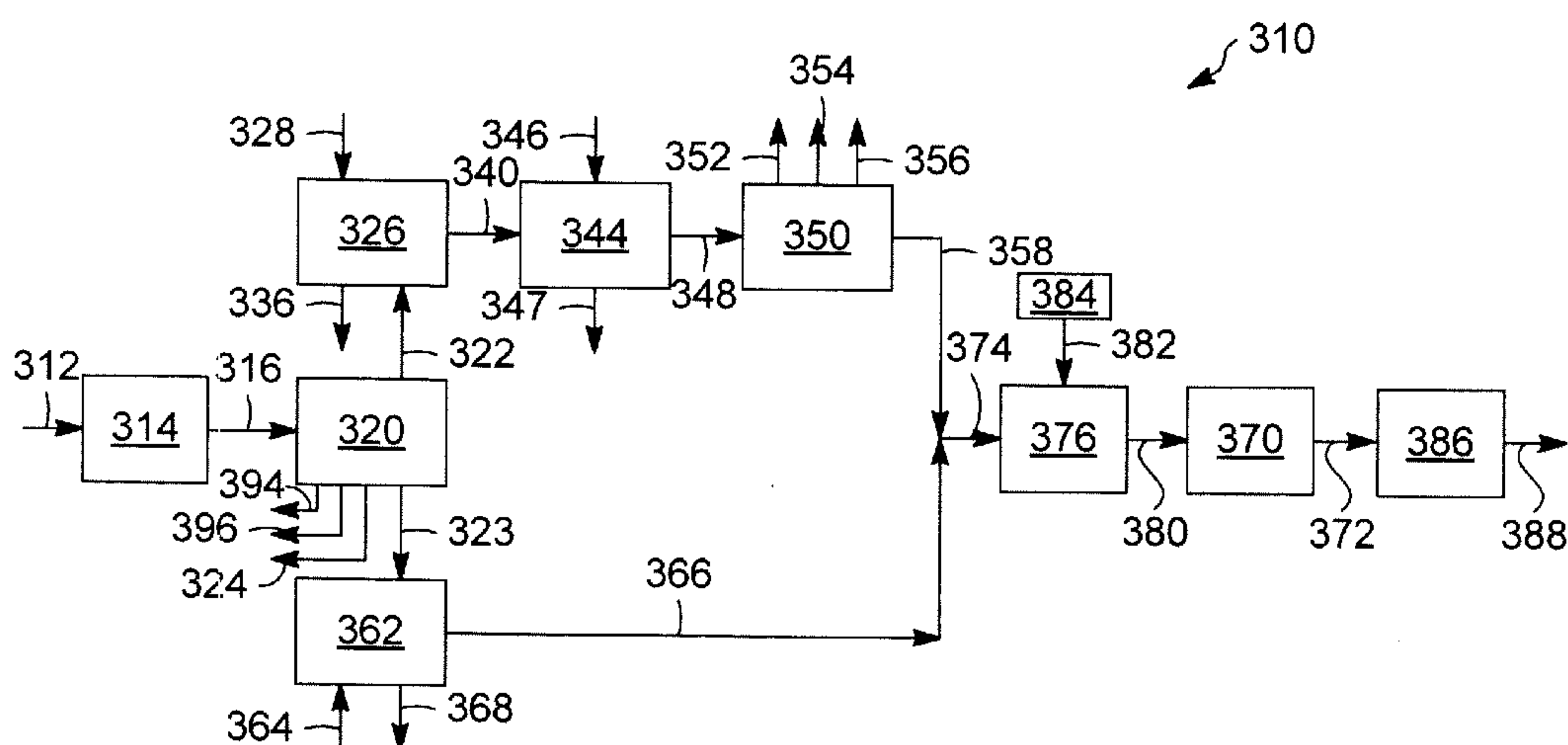
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(57) Abstract: Water and/or oxygenate content in olefin cracking feeds is/are reduced or minimized to enhance light olefin produc-
tion via integrated oxygenate conversion and product olefin cracking.

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ENHANCED OXYGENATE CONVERSION AND PRODUCT CRACKING INTEGRATION

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to the conversion of oxygenates to olefins and,
5 more particularly, to light olefins.

[0002] A major portion of the worldwide petrochemical industry is concerned with the
production of light olefin materials and their subsequent use in the production of numerous
important chemical products via polymerization, oligomerization, alkylation and the like
well-known chemical reactions. Light olefins include ethylene, propylene and mixtures
10 thereof. These light olefins are essential building blocks for the modern petrochemical and
chemical industries. A major source for these materials in present day refining is the steam
cracking of petroleum feeds. For various reasons including geographical, economic, political
and diminished supply considerations, the art has long sought a source other than petroleum
for the massive quantities of raw materials that are needed to supply the demand for these
15 light olefin materials.

[0003] The search for alternative materials for light olefin production has led to the use of
oxygenates such as alcohols and, more particularly, to the use of methanol, ethanol, and
higher alcohols or their derivatives such as dimethyl ether, diethyl ether, etc., for example.
Molecular sieves such as microporous crystalline zeolite and non-zeolitic catalysts,
20 particularly silicoaluminophosphates (SAPO), are known to promote the conversion of
oxygenates to hydrocarbon mixtures, particularly hydrocarbon mixtures composed largely of
light olefins.

[0004] Such processing of oxygenates to form light olefins is commonly referred to as a
methanol-to-olefin (MTO) process, as methanol alone or together with other oxygenate
25 materials such as dimethyl ether (DME) is typically an oxygenate material most commonly
employed therein. Such processing typically produces or results in a range of olefin reaction
products as well as unreacted oxygenates and other trace oxygenates. Typical or common
MTO processing schemes include an oxygenate absorber whereby circulated water is used to
absorb oxygenates, e.g., methanol and DME, from the light olefin product. This oxygenate-
30 containing circulated water is subsequently stripped in an oxygenate stripper to recover
methanol and DME, with such recovered materials ultimately recycled to the oxygenate

conversion reactor. The oxygenate conversion product stream resulting from the oxygenate absorber is passed to a CO₂ removal zone wherein the dewatered oxygenate conversion product stream is contacted with caustic solution to remove carbon dioxide and produce a caustic treated reactor product stream such as for subsequent processing through an
 5 appropriate light olefins recovery system.

[0005] Carbonyls, such as acetaldehyde, are common trace oxygenates in the oxygenate conversion reactor effluent and will typically be absorbed in the circulated water. Aldehydes in MTO effluent may, for example, include formaldehyde, acetaldehyde, propionaldehyde, butyraldehyde, and crotonaldehyde. These compounds may be in the MTO reactor feed,
 10 created as reaction side products, or formed in processing downstream of the reactor.

[0006] The amounts of light olefins resulting from such oxygenate to olefin processing can be further increased by reacting, i.e., cracking, heavier hydrocarbon products, particularly heavier olefins such as C₄ and C₅ olefins, to light olefins. For example, commonly assigned, US 5,914,433 to Marker discloses a process for the production of light olefins comprising
 15 olefins having from 2 to 4 carbon atoms per molecule from an oxygenate feedstock. The process comprises passing the oxygenate feedstock to an oxygenate conversion zone containing a metal aluminophosphate catalyst to produce a light olefin stream. A propylene stream and/or mixed butylene is fractionated from said light olefin stream and cracked to enhance the yield of ethylene and propylene products. This combination of light olefin
 20 product and propylene and butylene cracking in a riser cracking zone or a separate cracking zone provides flexibility to the process which overcomes the equilibrium limitations of the aluminophosphate catalyst. In addition, the invention provides the advantage of extended catalyst life and greater catalyst stability in the oxygenate conversion zone.

25 [0007] Molecular sieves such as silicalite catalyst materials used in olefin cracking desirably convert oxygenates to olefins. Such processing, however, also typically produces or forms coke and water. The formation coke may act to at least temporarily deactivate the catalyst. Such catalysts can generally be regenerated by burning or otherwise removing the coke. Permanent catalyst deactivation, however, can occur such as through the mechanism of
 30 hydrothermal dealumination of silicalite catalyst materials.

[0008] Thus, while the integration of an olefin cracking processing, such as to advantageously monetize the C₄+ olefins via conversion of a substantial portion of such C₄+

olefins to generally more commercially desirable propylene and ethylene, is of significant economic interest, such processing integration can be subject to certain processing complications or limitations.

[0009] For example, trace oxygenates and water are commonly present in the C₄+ olefinic product stream produced via MTO processing. Consequently, processing such trace oxygenate and water-containing C₄+ olefinic product streams in an olefin cracking reactor can detrimentally result in a more rapid permanent deactivation of the olefin cracking catalyst and can at least temporarily suppress activity through additional coke formation. Moreover, oxygenates in the feed can decompose to form water. Thus, the cumulative effects of water present in the olefin cracking feed and water generated from oxygenate decomposition can contribute to permanent deactivation.

[0010] In view thereof, there is an ongoing need and a demand for improved processing and systems for the conversion of oxygenates to olefins and, more particularly, for such processing and systems such as to result in an increase in the relative amount of light olefins such as via either or both more effective and more efficient integration of oxygenate conversion and product olefin cracking.

SUMMARY OF THE INVENTION

[0011] A general object of the invention is to provide or result in improved processing of an oxygenate-containing feedstock to light olefins.

[0012] A more specific objective of the invention is to overcome one or more of the problems described above.

[0013] A general object of the invention can be attained, at least in part, through a process for producing light olefins from an oxygenate-containing feedstock. In accordance with one preferred embodiment, such a process involves contacting the oxygenate-containing feedstock in an oxygenate conversion reactor with an oxygenate conversion catalyst and at reaction conditions effective to convert the oxygenate-containing feedstock to form an oxygenate conversion effluent stream comprising light olefins, C₄+ hydrocarbons and oxygenates. At least a portion of the oxygenate conversion product stream is treated in a hydrocarbon recovery system to recover light olefins and to form a C₄+ hydrocarbon fraction stream including C₄+ hydrocarbons and oxygenates. The C₄+ hydrocarbon fraction stream is treated to form a treated C₄+ hydrocarbon fraction stream containing oxygenates in a relative

amount of less than 800 ppmw equivalent water. The process further involves contacting at least a portion of the treated C₄+ hydrocarbon stream in an olefin cracking reactor with an olefin cracking catalyst and at reaction conditions effective to convert C₄ and C₅ olefins therein contained to a cracked olefins effluent stream comprising light olefins.

5 [0014] The prior art generally fails to provide processing schemes and arrangements for the conversion of an oxygenate-containing feedstock to olefins, particularly light olefins and which processing is as effective and efficient as may be desired for the integration of oxygenate conversion and product olefin cracking. More particularly, the presence of oxygenates and/or water in oxygenate conversion products streams and thus in the feed to
10 downstream product olefin cracking has not been addressed by the prior art in a manner that is as effective or efficient as may be desired.

[0015] A process for producing light olefins from an oxygenate-containing feedstock, in accordance with yet another embodiment involves similarly contacting the oxygenate-containing feedstock in an oxygenate conversion reactor with an oxygenate
15 conversion catalyst and at reaction conditions effective to convert the oxygenate-containing feedstock to an oxygenate conversion product stream comprising light olefins, C₄+ hydrocarbons and oxygenates. At least a portion of the oxygenate conversion product stream is treated in a hydrocarbon recovery system to recover light olefins and to form a C₄+ hydrocarbon fraction stream including C₄+ hydrocarbons and oxygenates. The C₄+
20 hydrocarbon fraction stream is washed in a contactor with a wash fluid comprising a sulfite-containing material to form a washed C₄+ hydrocarbon fraction stream containing oxygenates in a relative amount of less than 600 ppmw equivalent water. At least a portion of the treated C₄+ hydrocarbon stream is contacted with an olefin cracking catalyst in an olefin cracking reactor at reaction conditions effective to convert C₄ and C₅ olefins therein contained to a
25 cracked olefins effluent stream that includes light olefins.

[0016] A system for converting oxygenates to light olefins in accordance with yet another embodiment also includes a reactor for contacting an oxygenate-containing feedstream with catalyst and converting the oxygenate-containing feedstream to form an oxygenate conversion effluent stream. The oxygenate conversion effluent stream includes light olefins,
30 C₄+ hydrocarbons and oxygenates. The system includes a hydrocarbon recovery system to recover light olefins and to form a C₄+ hydrocarbon fraction stream including C₄+ hydrocarbons and oxygenates. The system further includes a treatment system for treating at

least a portion of the C₄+ hydrocarbon fraction stream with a wash stream to form a treated C₄+ hydrocarbon fraction stream containing oxygenates in a relative amount of less than 800 ppmw equivalent water. The system also further includes a reactor for contacting at least a portion of the treated C₄+ hydrocarbon fraction stream with catalyst and converting C₄ and C₅ olefins therein contained to a cracked olefin effluent stream comprising light olefins.

[0017] As used herein, references to "light olefins" are to be understood to generally refer to C₂ and C₃ olefins, i.e., ethylene and propylene, alone or in combination.

[0018] "Oxygenates" are hydrocarbons that contain one or more oxygen atoms. Typical oxygenates include alcohols and ethers, for example.

[0019] References to "C_x hydrocarbon" are to be understood to refer to hydrocarbon molecules having the number of carbon atoms represented by the subscript "x". Similarly, the term "C_x-containing stream" refers to a stream that contains C_x hydrocarbon. The term "C_x+ hydrocarbons" refers to hydrocarbon molecules having the number of carbon atoms represented by the subscript "x" or greater. For example, "C₄+ hydrocarbons" include C₄, C₅ and higher carbon number hydrocarbons.

[0020] "Equivalent water" is defined as the sum total oxygen in a stream present as oxygenates and water, expressed as water.

[0021] Other objects and advantages will be apparent to those skilled in the art from the following detailed description taken in conjunction with the appended claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. 1 is a simplified schematic diagram of an integrated oxygenate conversion and olefin cracking process in accordance with one preferred embodiment.

[0023] FIG. 2 is a simplified schematic diagram of an integrated oxygenate conversion and olefin cracking process in accordance with another preferred embodiment.

[0024] FIG. 3 is a simplified schematic diagram of an integrated oxygenate conversion and olefin cracking process in accordance with yet another preferred embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0025] As described above, oxygenate conversion processing to produce olefins can advantageously be integrated with olefin cracking processing to result in increased relative amounts of light olefin products through either or both reducing the water content and/or

reducing the oxygenate content of the feed to the olefin cracking zone. Such processing may be embodied in a variety of processing arrangements. As representative, FIG. 1 illustrates a simplified schematic process flow diagram for a process scheme, generally designated by the reference numeral 310, for the conversion of oxygenates to olefins and integrated with product olefin cracking for increased light olefin production in accordance with one preferred embodiment.

[0026] More particularly, in the process scheme 310, an oxygenate-containing feedstock or feedstream 312 such as generally composed of light oxygenates such as one or more of methanol, ethanol, dimethyl ether, diethyl ether, or mixtures thereof, is introduced into an oxygenate conversion zone or reactor section 314 wherein the oxygenate-containing feedstock contacts with an oxygenate conversion catalyst at reaction conditions effective to convert the oxygenate-containing feedstock and to form an oxygenate conversion effluent stream comprising fuel gas hydrocarbons, light olefins, and C₄+ hydrocarbons, in a manner as is known in the art, such as, for example, utilizing a fluidized bed reactor.

[0027] As will be appreciated by those skilled in the art and guided by the teachings herein provided, such a feedstock may be commercial grade methanol, crude methanol or any combination thereof. Crude methanol may be an unrefined product from a methanol synthesis unit. Those skilled in that art and guided by the teachings herein provided will understand and appreciate that in the interest of factors such as improved catalyst stability, embodiments utilizing higher purity methanol feeds may be preferred. Thus, suitable feeds in such embodiments may comprise methanol or a methanol and water blend, with possible such feeds having a methanol content of between 65% and 100% by weight, preferably a methanol content of between 80% and 100% by weight and, in accordance one preferred embodiment, a methanol content of between 95% and 100% by weight.

[0028] A methanol-to-olefin unit feedstream may comprise between 0 and 35 wt-% and more preferably between 5 and 30 wt-% water. The methanol in the feedstream may comprise between 70 and 100 wt-% and more preferably between 75 and 95 wt-% of the feedstream. The ethanol in the feedstream may comprise between 0.01 and 0.5 wt-% and more typically between 0.1 and 0.2 wt-% of the feedstream although higher concentrations may be beneficial. When methanol is the primary component in the feedstream, the higher alcohols in the feedstream may comprise between 200 and 2000 wppm and more typically between 500 and 1500 wppm. Additionally, when methanol is the primary component in the

feedstream, dimethyl ether in the feedstream may comprise between 100 and 20,000 wppm and more typically between 200 and 10,000 wppm.

[0029] The invention, however, also contemplates and encompasses embodiments wherein the oxygenate-containing feedstock is primarily dimethyl ether and, in certain
5 embodiments, the oxygenate-containing feedstock is essentially dimethyl ether, either alone or with no more than insubstantial amounts of other oxygenate materials.

[0030] Reaction conditions for the conversion of oxygenates to light olefins are known to those skilled in the art. Preferably, in accordance with particular embodiments, reaction conditions comprise a temperature between 200° and 700°C, more preferably between 300°
10 and 600°C, and most preferably between 400° and 550°C. As will be appreciated by those skilled in the art and guided by the teachings herein provided, the reactions conditions are generally variable such as dependent on the desired products. The light olefins produced can have a ratio of ethylene to propylene of between 0.5 and 2.0 and preferably between 0.75 and 1.25. If a higher ratio of ethylene to propylene is desired, then the reaction temperature is
15 generally desirably higher than if a lower ratio of ethylene to propylene is desired. In accordance with one preferred embodiment, a feed temperature range between 120° and 210°C is preferred. In accordance with another preferred embodiment a feed temperature range of between 180° and 210°C is preferred. In accordance with one preferred embodiment, the temperature is desirably maintained below 210°C to avoid or minimize thermal
20 decomposition.

[0031] As described above, the oxygenate conversion reactor section 314 produces or results in an oxygenate conversion product or effluent stream 316 such as generally comprising hydrocarbon product materials such as fuel gas hydrocarbons, light olefins, and C₄+ hydrocarbons; by-product water; and remaining oxygenates such as methanol, dimethyl
25 ether (DME) and other trace oxygenates including carbonyls such as acetaldehyde. The oxygenate conversion effluent stream 316 is passed to a hydrocarbon recovery system such as includes an effluent treatment zone 320 such as results in at least a compressed oxygenate conversion effluent vapor stream 322, an oxygenate conversion effluent liquid stream 323, a heavily laden water stream 394 containing heavy oxygenates and other heavy hydrocarbons, a relatively clean water stream 396 and a stream of circulated water 324. In practice, such a
30 compressed oxygenate conversion effluent stream 322 may be the result of one or more compressor stages. Further, the stream of circulated water 324 may include water from one or

more interstage condensations as well as water from various product recovery units or zones including, for example, wash water columns and the like.

[0032] In practice, C₄+ hydrocarbons, water and residual oxygenates will typically be present in both the oxygenate conversion effluent vapor stream 322 and the oxygenate
5 conversion effluent liquid stream 323.

[0033] The compressed oxygenate conversion effluent stream 322 or at least a portion thereof, is introduced into an oxygenate absorber zone 326, such as in the form of at least one absorber column. In the oxygenate absorber zone 326, at least a portion of oxygenates such as methanol, dimethyl ether (DME) and other trace oxygenates including carbonyls such as
10 acetaldehyde such as may be present therein can be absorbed in circulated water, such as here represented by the flow stream 328, and thus are separated from the hydrocarbon product materials.

[0034] The oxygenate absorber zone 326 forms or results in an oxygenate-rich water stream 336 such as comprises such oxygenate materials in water and a stream 340 such as
15 comprises such hydrocarbon product materials. As discussed in greater detail below, the hydrocarbon product material stream 340 may additionally contain some residual amounts of oxygenates.

[0035] The hydrocarbon product material stream 340, if desired, can be further processed such as by being introduced into a caustic scrubber zone 344 and appropriately treated, such
20 as by being conventionally washed with a caustic solution, such as introduced through the line 346 to neutralize acid gases, and dried forming a purge stream 347 and a treated stream 348.

[0036] The treated stream 348 can then be appropriately introduced into a desired gas concentration and product recovery system 350. Gas concentration and product recovery
25 systems such as used for the processing of the effluent resulting from such oxygenate conversion processing are well known to those skilled in the art and do not generally form limitations on the broader practice of the invention as those skilled in the art and guided by the teachings herein provided will appreciate.

[0037] In the gas concentration and product recovery system 350, the remaining
30 hydrocarbon product material can be processed such as to form desired hydrocarbon fraction streams. For example, the gas concentration and product recovery system 350 may desirably form a fuel gas stream 352, an ethylene stream 354, a propylene stream 356 and a mixed C₄+

hydrocarbon stream 358, such as generally composed of butylene and heavier hydrocarbons, and may additionally contain some trace or small amounts of oxygenates.

[0038] The oxygenate conversion effluent liquid stream 323 or at least a portion thereof can be further processed such as being passed to a wash zone 362 such as comprising at least one wash column wherein the oxygenate conversion effluent liquid stream 323 can be appropriately treated such as via countercurrent contact with a wash fluid of recycle water 364, to form an appropriately washed stream 366 and a resulting recycle water stream 368.

[0039] In the embodiment shown in FIG. 1, the mixed C₄+ hydrocarbon stream 358 and the washed stream 366 are combined to form a stream 374 that is introduced into a treatment zone, designated by the reference numeral 376. In accordance with a preferred embodiment and as described in greater detail below, in the treatment zone 376, the combined C₄+ hydrocarbon fraction stream 374 is treated to form a treated C₄+ hydrocarbon fraction stream 380 containing oxygenates in an appropriately reduced or minimized relative amount.

[0040] In the treatment zone 376, the process scheme 310 treats the combined feed stream 374 with wash fluid of preferably a sulfite-containing material such as introduced into the treatment zone 376 as shown by the line 382 from a sulfite-containing reservoir 384 added to in order to form the treated C₄+ hydrocarbon fraction stream 380 containing oxygenates in an appropriately reduced or minimized relative amount.

[0041] As used herein, references to a "sulfite-containing material" are to be understood to include sulfite compounds, bisulfite compounds and mixtures thereof. Sodium bisulfite is an example of one preferred "sulfite-containing material" for use in practice of such aspect of the invention.

[0042] The effective treatment of such C₄+ containing feed streams with such a sulfite-containing material in accordance with one preferred embodiment can be realized by washing or otherwise effectively treating the combined stream 374 with a solution of a sulfite compound comprising an alkali metal or an alkaline earth metal cation in an element such as a sulfite wash column. Examples of suitable such cation materials include sodium, potassium, magnesium and calcium.

[0043] If desired or required, the treated C₄+ hydrocarbon fraction stream 380, in whole or in part, can then be introduced into a drier section 370 wherein such stream materials can be appropriately dried, such as in a manner known in the art, to remove or otherwise

effectively reduce the water or moisture content thereof and such as to form a dried treated C₄+hydrocarbon fraction stream 372.

[0044] At least a portion of the dried treated C₄+hydrocarbon fraction stream 372 is subsequently appropriately introduced into an olefin cracking reactor section 386 wherein the at least a portion of the process stream 372 contacts with an olefin cracking catalyst and at reaction conditions, in a manner as is known in the art, effective to convert C₄ and C₅ olefins therein contained to a cracked olefins effluent stream 388 comprising light olefins.

[0045] In accordance with a preferred embodiment, it is desirable that the feed to such an olefin cracking reactor preferably contain oxygenates in a relative amount of less than 800 ppmw equivalent water. In certain, more preferred embodiments, it is desirable that the feed to such an olefin cracking reactor preferably contain oxygenates in a relative amount of less than 600 ppmw equivalent water. In certain, even more preferred embodiments, it is desirable that the feed to such an olefin cracking reactor preferably contain oxygenates in a relative amount of less than 200 ppmw equivalent water.

[0046] If desired, the cracked olefins effluent stream 388 or selected portions thereof can subsequently be appropriately processed in manner known in the art or as will be recognized by those skilled in the art and guided by the teaching herein provided. For example, the cracked olefins effluent stream 388 or selected portions thereof can subsequently be appropriately processed through one or more cooler sections to appropriately cool the stream contents, one or more product separation sections to appropriately separate product materials therein contained and/or one or more product recovery sections to permit appropriate recovery of selected products therefrom. In one preferred embodiment, such subsequent processing involves processing of the cracked olefins effluent stream 388 or selected portions thereof through the hydrocarbon recovery section 318 or at least selected portions thereof, e.g., the gas concentration and product recovery system 350.

[0047] Those skilled in the art and guided by the teachings herein provided, as an alternative to such sulfite treatment for oxygenate content reduction or minimization, may consider modification of the design or operation of the water wash column of the wash zone 362. More specifically, by appropriately increasing the water flow rate and the number of stages in such a water wash column, the remaining oxygenate content in the resulting treated stream can be appropriately reduced.

[0048] The washed stream can then be introduced into a drier section 370 wherein the washed stream can be appropriately dried, such as in a manner known in the art, to remove or otherwise effectively reduce the water or moisture content thereof and such as to form the dried stream 372. For example, the washed materials can be routed to a depropanizer column or other suitable drying column to effect the desired removal of water. Alternatively, a feed

5 [0049] Those skilled in the art and guided by the teachings herein provided will generally understand and appreciate that in the absence of such water wash column modification, such oxygenate conversion and subsequent product processing will typically result in the bulk of the oxygenates being present in the process stream resulting from the wash zone, e.g., in the water wash column overhead stream. Thus, FIG. 2 illustrates a simplified schematic process flow diagram for a process scheme, generally designated by the reference numeral 410, for the conversion of oxygenates to olefins and integrated with product olefin cracking for increased light olefin production in accordance with another preferred embodiment and

10 wherein the process stream resulting from a wash zone, as described above, is alone treated with sulfite-containing material to effect the desired reduction or minimization of oxygenate content.

[0050] The process scheme 410 is in general respects similar to the process scheme 310 described above. For example, in the process scheme 410, an oxygenate-containing feedstock or feedstream 412, such as described above, is introduced into an oxygenate conversion zone or reactor section 414 wherein the oxygenate-containing feedstock contacts with an oxygenate conversion catalyst at reaction conditions effective to convert the oxygenate-containing feedstock and to form an oxygenate conversion effluent stream comprising fuel gas hydrocarbons, light olefins, and C₄+ hydrocarbons, in a manner as is known in the art,

20 such as, for example, utilizing a fluidized bed reactor.

[0051] As described above, the oxygenate conversion reactor section 414 produces or results in an oxygenate conversion product or effluent stream 416 such as generally comprising hydrocarbon product materials such as fuel gas hydrocarbons, light olefins, and C₄+ hydrocarbons; by-product water; and remaining oxygenates such as methanol, dimethyl ether (DME) and other trace oxygenates including carbonyls such as acetaldehyde. The

30 oxygenate conversion effluent stream 416 is passed to a hydrocarbon recovery system such as includes an effluent treatment zone 420 such as results in at least a compressed oxygenate

conversion effluent vapor stream 422, an oxygenate conversion effluent liquid stream 423, a heavily laden water stream 494 containing heavy oxygenates and other heavy hydrocarbons, a relatively clean water stream 496 and a stream of circulated water 424.

[0052] As identified above, C₄+ hydrocarbons, water and residual oxygenates will typically be present in both the oxygenate conversion effluent vapor stream 422 and the oxygenate conversion effluent liquid stream 423.

[0053] As in the above-described embodiment, the compressed oxygenate conversion effluent stream 422 or at least a portion thereof, is introduced into an oxygenate absorber zone 426, such as in the form of at least one absorber column. As in the above-described embodiment, in the oxygenate absorber zone 426, at least a portion of oxygenates such as methanol, dimethyl ether (DME) and other trace oxygenates including carbonyls such as acetaldehyde such as may be present therein can be absorbed in circulated water, here designated and represented by the flow stream 428, and thus are separated from the hydrocarbon product materials

[0054] As described above, the oxygenate absorber zone 426 forms or results in an oxygenate-rich water stream 436 such as comprises such oxygenate materials in water and a stream 440 such as comprises such hydrocarbon product materials.

[0055] The hydrocarbon product material stream 440, if desired and as described above, can be further processed such as by being introduced into a caustic scrubber zone 444 and appropriately treated, such as by being conventionally washed with a caustic solution, such as provided via a line 446, to neutralize acid gases and appropriately dried, forming a purge stream 447 and a treated stream 448.

[0056] The treated stream 448 can then be appropriately introduced into a desired gas concentration and product recovery system 450 such as described above such as to form desired hydrocarbon fraction streams. For example, the gas concentration and product recovery system 450 may desirably form a fuel gas stream 452, an ethylene stream 454, a propylene stream 456 and a mixed C₄+ hydrocarbon stream 458, such as generally composed of butylene and heavier hydrocarbons.

[0057] The oxygenate conversion effluent liquid stream 423 or at least a portion thereof can be further processed such as being passed to a wash zone 462 such as comprising at least one wash column wherein the oxygenate conversion effluent liquid stream 423 can be

appropriately treated such as via countercurrent contact with a wash fluid of recycle water 464, to form an appropriately washed stream 466 and a resulting recycle water stream 468.

[0058] As identified above, between such a mixed C₄+ hydrocarbon stream 458 and such a washed stream 466, the vast bulk of the oxygenates will typically be present in the washed stream 466, this embodiment introduces such hydrocarbon-containing stream into a treatment zone 476, for treatment with a sulfite-containing material, such as described above, introduced into the treatment zone 476 as shown by the line 482 from a sulfite-containing reservoir 484 added to in order to form the treated C₄+ hydrocarbon fraction stream 477 containing oxygenates in an appropriately reduced or minimized relative amount.

[0059] At least a portion of the treated C₄+ hydrocarbon fraction stream 477 can subsequently be appropriately combined with the mixed C₄+ hydrocarbon stream 458 such as to form a combined stream 478 having an appropriately reduced oxygenate content. Such a combined stream 478 or portion thereof can then be introduced into a drier section 470 wherein such stream materials can be appropriately dried, such as in a manner known in the art, to remove or otherwise effectively reduce the water or moisture content thereof and such as to form a dried stream 472.

[0060] At least a portion of the dried process stream 472 is then introduced into an olefin cracking reactor section 486 wherein the at least a portion of the process stream 472 contacts with an olefin cracking catalyst and at reaction conditions, in a manner as is known in the art, effective to convert C₄ and C₅ olefins therein contained to a cracked olefins effluent stream 488 comprising light olefins and such as may be appropriately processed as desired.

[0061] As described above, in accordance with a preferred embodiment, it is desirable that the feed to such an olefin cracking reactor preferably contain oxygenates in a relative amount of less than 800 ppmw equivalent water, more preferably, in a relative amount of less than 600 ppmw equivalent water and, in accordance with certain embodiments, in a relative amount of less than 200 ppmw equivalent water.

[0062] While the embodiment of FIG. 2 has been described making specific reference to an embodiment wherein the drier section 470 acts on the combined stream 478 or portion thereof, those skilled in the art and guided by the teachings herein provided will appreciate that if desired or preferred, such a drier section may alternatively be appropriately disposed such as to act on, e.g., dry, the treated C₄+ hydrocarbon fraction stream 477 prior to combination, in whole or in part, with the mixed C₄+ hydrocarbon stream 458.

[0063] Now making reference to FIG. 3, there is illustrated a simplified schematic process flow diagram for a process scheme, generally designated by the reference numeral 510, for the conversion of oxygenates to olefins and integrated with product olefin cracking for increased light olefin production in accordance with yet another preferred embodiment.

5 [0064] The process scheme 510 is similar to the scheme 310 described above in that an oxygenate-containing feedstock or feedstream 512, such as described above, is introduced into an oxygenate conversion zone or reactor section 514 wherein the oxygenate-containing feedstock contacts with an oxygenate conversion catalyst at reaction conditions effective to convert the oxygenate-containing feedstock and to form an oxygenate conversion effluent
10 stream comprising fuel gas hydrocarbons, light olefins, and C₄+ hydrocarbons, in a manner as is known in the art.

[0065] As described above, the oxygenate conversion reactor section 514 produces or results in an oxygenate conversion product or effluent stream 516 such as generally comprising hydrocarbon product materials such as fuel gas hydrocarbons, light olefins, and
15 C₄+ hydrocarbons; by-product water; and remaining oxygenates such as methanol, dimethyl ether (DME) and other trace oxygenates including carbonyls such as acetaldehyde. The oxygenate conversion effluent stream 516 is passed to a hydrocarbon recovery system such as includes an effluent treatment zone 520 such as results in at least a compressed oxygenate conversion effluent vapor stream 522, an oxygenate conversion effluent liquid stream 523, a
20 heavily laden water stream 594 containing heavy oxygenates and other heavy hydrocarbons, a relatively clean water stream 596 and a stream of circulated water 524.

[0066] As in the above-described embodiment, the compressed oxygenate conversion effluent stream 522 or at least a portion thereof, is introduced into an oxygenate absorber zone 526, such as in the form of at least one absorber column. In the oxygenate absorber zone
25 526, at least a portion of oxygenates such as methanol, dimethyl ether (DME) and other trace oxygenates including carbonyls such as acetaldehyde such as may be present therein can be absorbed in circulated water, such as here represented by the flow stream 528, and thus are separated from the hydrocarbon product materials.

[0067] The oxygenate absorber zone 526 forms or results in an oxygenate-rich water
30 stream 536 such as comprises such oxygenate materials in water and a stream 540 such as comprises such hydrocarbon product materials. The hydrocarbon product material stream 540 may additionally contain some residual amounts of oxygenates.

[0068] The hydrocarbon product material stream 540, if desired and as described above, can be further processed such as by being introduced into a caustic scrubber zone 544 and appropriately treated, such as by being conventionally washed with a caustic solution, such as introduced through the line 546 to neutralize acid gases, and dried forming a purge stream 547 and a treated stream 548.

[0069] The treated stream 548 can then be appropriately introduced into a desired gas concentration and product recovery system 550 such as to form desired hydrocarbon fraction streams, e.g., a fuel gas stream 552, an ethylene stream 554, a propylene stream 556 and a mixed C₄+ hydrocarbon stream 558, such as generally composed of butylene and heavier hydrocarbons, and may additionally contain some trace or small amounts of oxygenates.

[0070] The oxygenate conversion effluent liquid stream 523 or at least a portion thereof can be further processed such as being passed to a wash zone 562 such as comprising at least one wash column wherein the oxygenate conversion effluent liquid stream 523 can be appropriately treated such as via countercurrent contact with a wash fluid of recycle water 564, to form an appropriately washed stream 566 and a resulting recycle water stream 568.

[0071] In the embodiment shown in FIG. 3, the mixed C₄+ hydrocarbon stream 558 and the washed stream 566 are combined to form a stream 574 that is introduced into an appropriate fractionation zone 577 such as in the form of a debutanizer column. The fractionation zone 577 forms or produces a first stream 579, such as in the form of a bottoms stream from such a fractionation zone debutanizer column, and having a high concentration of heavier oxygenates and a second stream 581, such as in the form of an overhead stream from such a fractionation zone debutanizer column, having a high concentration of lighter oxygenates (methanol and DME, for example).

[0072] The heavier oxygenates concentrated in the stream 579 can advantageously be processed through a sulfite treatment zone 576 wherein the materials are treated with a sulfite-containing material, such as described above, such as introduced into the treatment zone 576 as shown by the line 582 from a sulfite-containing reservoir 584 such as to form a treated stream 583.

[0073] If desired or required, the treated stream 583, in whole or in part, can then be introduced into a drier section 570 wherein the treated stream can be appropriately dried, such as in a manner known in the art, to remove or otherwise effectively reduce the water or moisture content thereof and such as to form a dried treated stream 572.

[0074] The lighter oxygenates concentrated in the stream 581 can be processed through an oxygenate recovery unit (ORU), such as is known in the art and here designated by the reference numeral 585 and appropriately dried to form a treated stream 587.

5 [0075] The treated stream 583 and the dried treated stream 572, either separately or together as shown as a stream 589 having an appropriately low oxygenate content can be introduced into an olefin cracking reactor section 586 wherein the at least a portion of the process stream 589 contacts with an olefin cracking catalyst and at reaction conditions, in a manner as is known in the art, effective to convert C₄ and C₅ olefins therein contained to a cracked olefins effluent stream 588 comprising light olefins.

10 [0076] In such embodiment, the concentrating of the heavier oxygenates in to C₅+ material can desirably serve to reduce or minimize the size of the required sulfite wash unit and the material flow rates therethrough.

[0077] Those skilled in the art and guided by the teaching herein provided will appreciate that through the appropriate pretreatment of olefin cracking feeds produced or resulting from oxygenate conversion processing, such as described above, excessive loss of olefin cracking catalyst activity and frequency of replacement can be desirably appropriately avoided or minimized.

15 [0078] The invention illustratively disclosed herein suitably may be practiced in the absence of any element, part, step, component, or ingredient which is not specifically disclosed herein.

20 [0079] In the foregoing detailed description, this invention has been described in relation to certain preferred embodiments thereof, and many details have been set forth for purposes of illustration. The scope of the claims should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole.

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CLAIMS :

1. A process for producing light olefins from an oxygenate-containing feedstock, said process comprising:

contacting the oxygenate-containing feedstock in an oxygenate conversion reactor with an oxygenate conversion catalyst and at reaction conditions effective to convert the oxygenate-containing feedstock to an oxygenate conversion product stream comprising light olefins, C₄+ hydrocarbons and oxygenates;

treating at least a portion of the oxygenate conversion product stream in a hydrocarbon recovery system (350, 450, 550) to recover light olefins and to form a C₄+ hydrocarbon fraction stream including C₄+ hydrocarbons and oxygenates;

treating the C₄+ hydrocarbon fraction stream to form a treated C₄+ hydrocarbon fraction stream containing oxygenates in a relative amount of less than 800 ppmw equivalent water; and

contacting at least a portion of the treated C₄+ hydrocarbon stream in an olefin cracking reactor (386, 486, 586) with an olefin cracking catalyst and at reaction conditions effective to convert C₄ and C₅ olefins therein contained to a cracked olefins effluent stream comprising light olefins.

2. The process of claim 1 wherein said treating of the C₄+ hydrocarbon fraction stream forms a treated C₄+ hydrocarbon fraction stream containing oxygenates in a relative amount of less than 600 ppmw equivalent water.

3. The process of claim 1 wherein said treating of the C₄+ hydrocarbon fraction stream forms a treated C₄+ hydrocarbon fraction stream containing oxygenates in a relative amount of no more than 200 ppmw equivalent water.

4. The process of claim 1 wherein said treating of the C₄+hydrocarbon fraction stream comprises:

washing at least a portion of the C₄+hydrocarbon fraction stream in a contactor (362, 462, 562) with a wash fluid comprising water to form the treated C₄+hydrocarbon fraction stream.

5. The process of claim 1 wherein said treating of the C₄+hydrocarbon fraction stream comprises:

washing at least a portion of the C₄+hydrocarbon fraction stream in a contactor (376, 476, 576) with a wash fluid comprising a sulfite-containing material to form the treated C₄+hydrocarbon fraction stream.

6. The process of claim 5 wherein the sulfite-containing material comprises a solution of a sulfite compound comprising an alkali metal or an alkaline earth metal cation.

7. The process of claim 6 wherein the sulfite compound comprises sodium cation.

8. The process of claims 6 wherein the sulfite compound comprises potassium cation.

9. The process of claim 1 wherein the oxygenate conversion product stream is processed to form at least a compressed oxygenate conversion effluent vapor stream and an oxygenate conversion effluent liquid stream and wherein at least a portion of the oxygenate conversion effluent liquid stream is washed with a sulfite-containing material to form the treated C₄+hydrocarbon fraction stream.

10. The process of claim 9 wherein at least a portion of the oxygenate conversion effluent liquid stream and at least a portion of the compressed oxygenate conversion effluent vapor stream are washed with a sulfite-containing material to form the treated C₄+hydrocarbon fraction stream.

11. The process of claim 1 wherein said treating the C₄+ hydrocarbon fraction stream comprises fractionation of at least a portion of the C₄+ hydrocarbon fraction stream to form a C₄+ stream and a C₅+ stream and wherein the C₅+ stream comprises the portion of C₄+ hydrocarbon fraction stream washed with a wash fluid comprising a sulfite-containing material.

12. A system (310, 410, 510) for converting oxygenates to light olefins, said system comprising:

a reactor (314, 414, 514) for contacting an oxygenate-containing feedstream with catalyst and converting the oxygenate-containing feedstream to form an oxygenate conversion effluent stream comprising light olefins, C₄+ hydrocarbons and oxygenates;

a hydrocarbon recovery system (350, 450, 550) to recover light olefins and to form a C₄+ hydrocarbon fraction stream including C₄+ hydrocarbons and oxygenates;

a treatment system (376, 476, 576) for treating at least a portion of the C₄+ hydrocarbon fraction stream with a wash stream to form a treated C₄+ hydrocarbon fraction stream containing oxygenates in a relative amount of less than 800 ppmw equivalent water; and

a reactor (386, 486, 586) for contacting at least a portion of the treated C₄+ hydrocarbon fraction stream with catalyst and converting C₄ and C₅ olefins therein contained to a cracked olefin effluent stream comprising light olefins.

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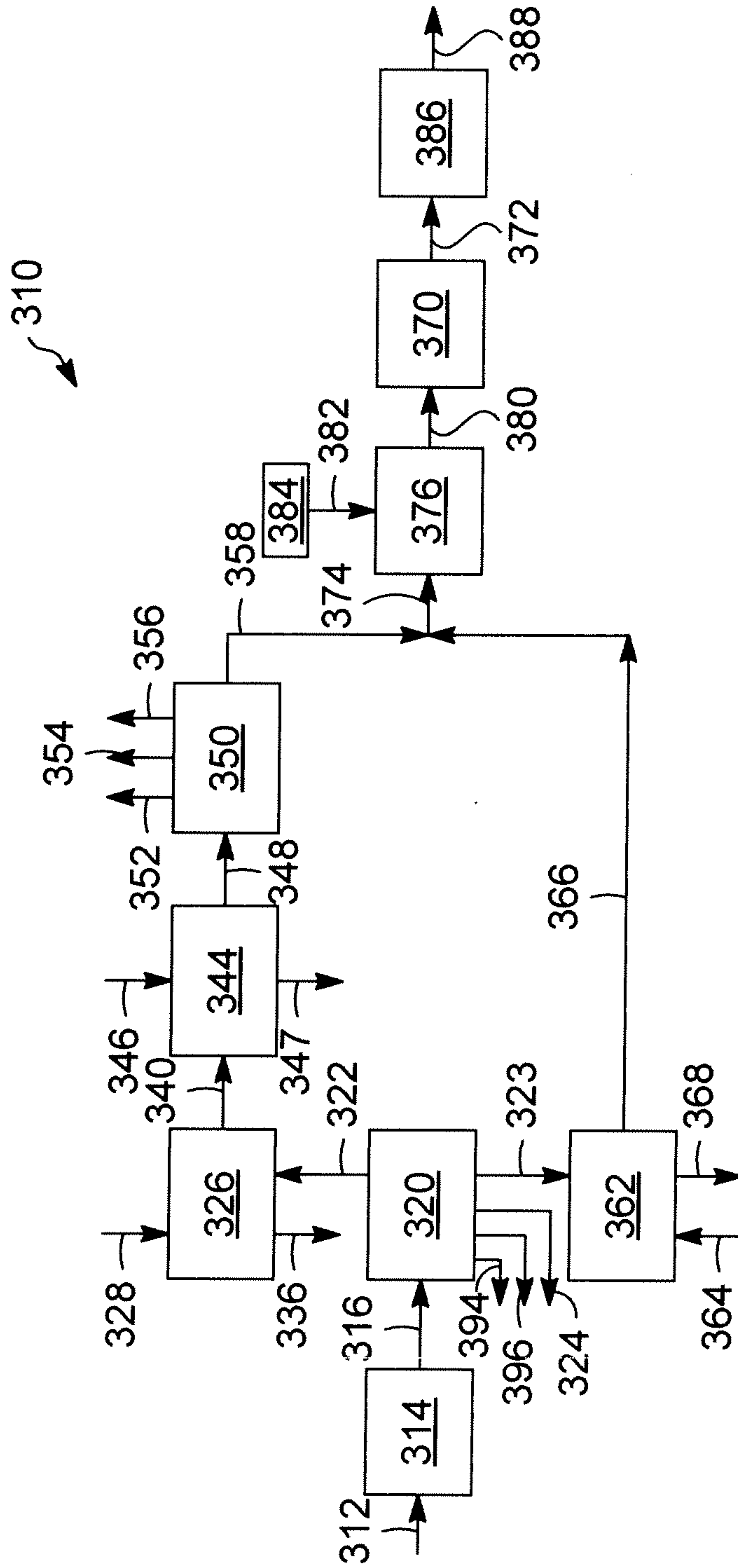


FIG. 1

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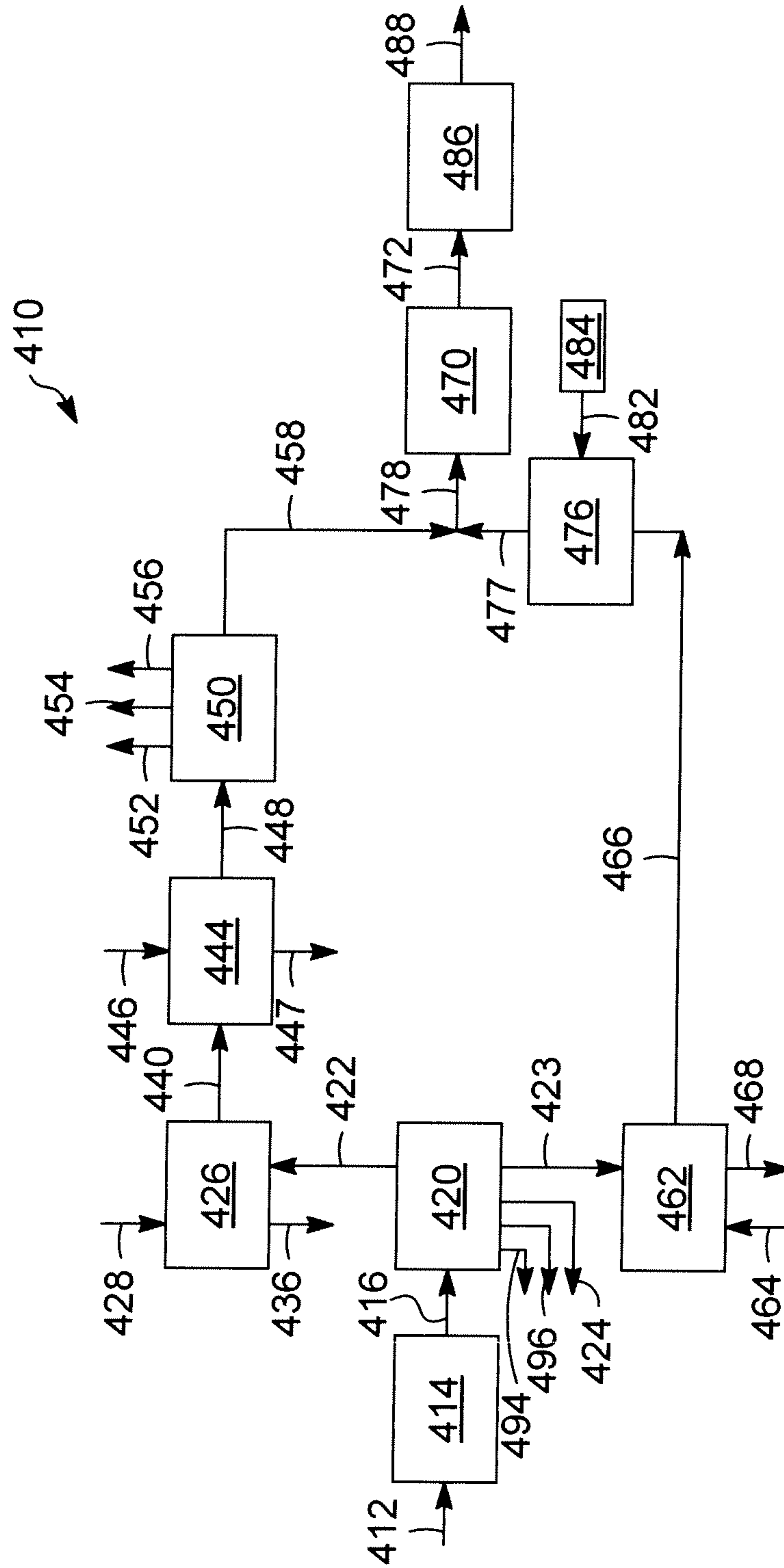


FIG. 2

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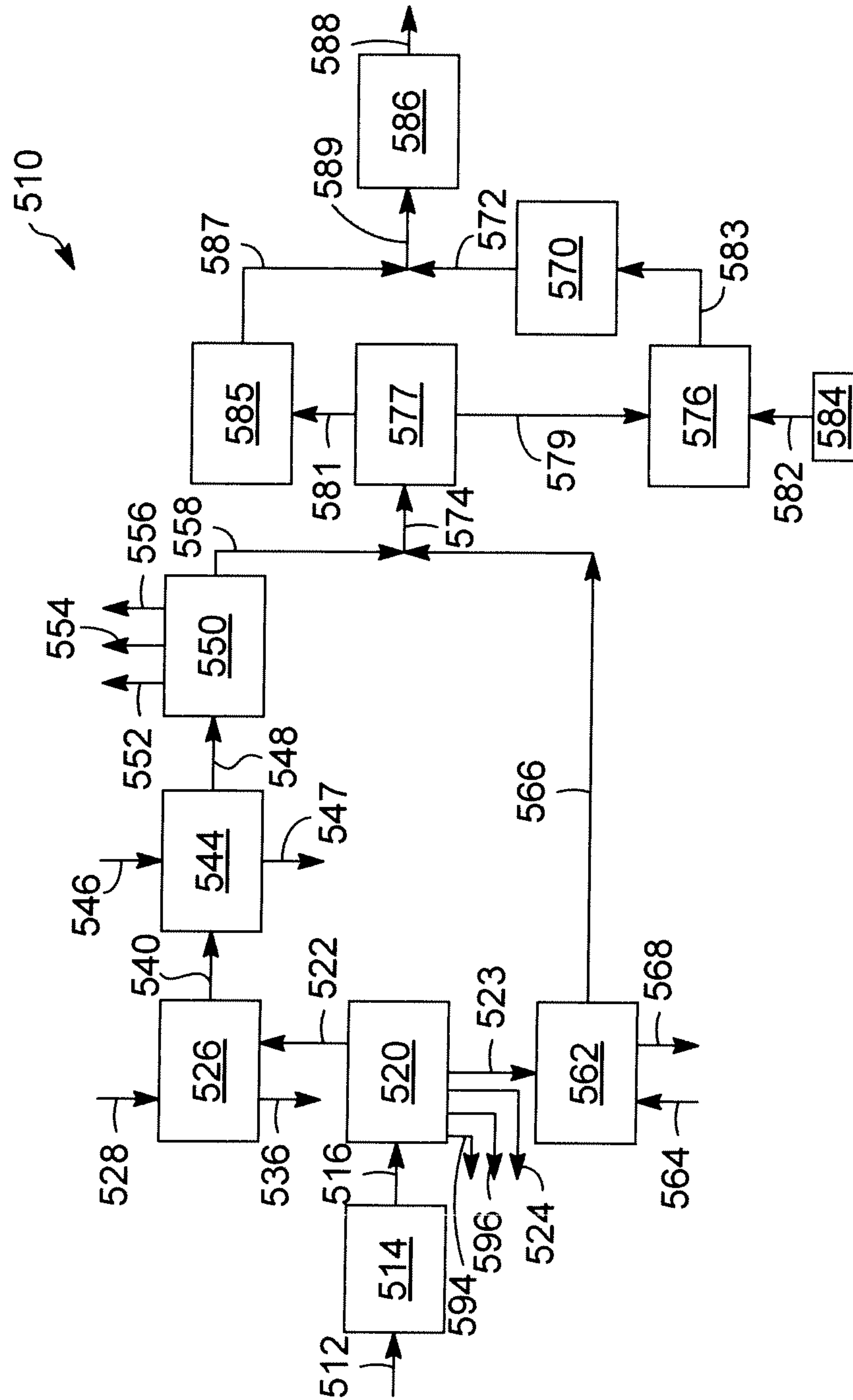


FIG. 3

