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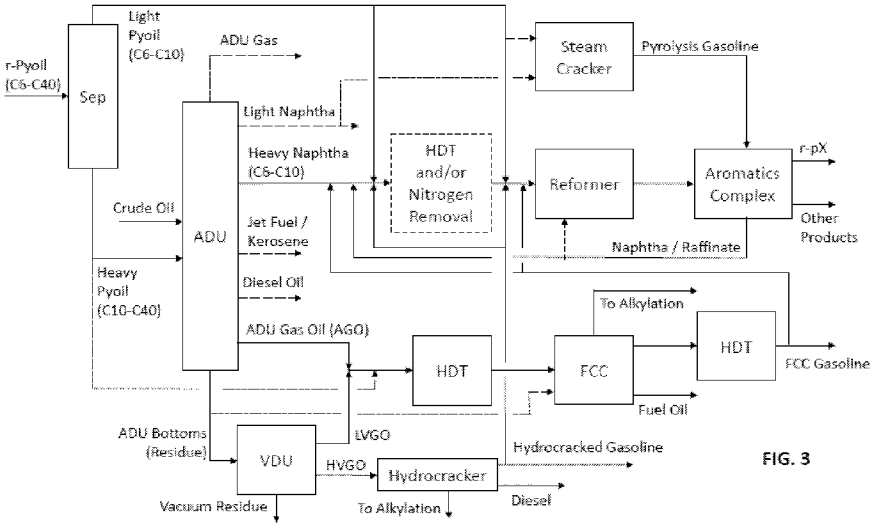


FIG. 3

(57) Abstract: Processes and facilities for producing a recycled content organic chemical compounds directly or indirectly from waste plastic. Processing schemes are described herein for converting waste plastic (or hydrocarbon having recycled content derived from waste plastic) into useful intermediate chemicals and final products. The processing schemes may comprise a process for reforming a recycled content pyrolysis oil (r-pyoil) stream to produce a reformate comprising recycled content aromatics (r-aromatics). In some aspects, the r-aromatics can be processed to provide recycled content paraxylene (r-paraxylene), which can then be used to provide recycled content terephthalic acid (r-TPA) and/or recycled content polyethylene terephthalate (r- PET).

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CATALYTIC REFORMING OF RECYCLED CONTENT LIGHT PYROLYSIS OIL

BACKGROUND

[0001] Aromatic compounds such as benzene, toluene, and xylenes are important industrial chemicals used in a variety of applications. Para-xylene is used to form dicarboxylic acids and esters, which are key chemical feedstocks in the production of polyesters and aromatics-based plasticizers. Most conventional production routes for these materials utilize fossil fuel-derived feeds.

[0002] Waste materials, especially non-biodegradable waste materials, can negatively impact the environment when disposed of in landfills after a single use. Thus, from an environmental standpoint, it is desirable to recycle as much waste material as possible. However, there still exist streams of low value waste that are nearly impossible or economically unfeasible to recycle with conventional recycling technologies. In addition, some conventional recycling processes produce waste streams that are themselves not economically feasible to recover or recycle, resulting in additional waste streams that must be disposed of or otherwise handled. Thus, it would be desirable to find additional synthesis routes for para-xylene and other aromatics that utilize waste materials, while also providing high-purity end products.

SUMMARY

[0003] In one aspect, the present technology concerns a method for producing recycled content para-xylene (r-pX), the method comprising reforming a naphtha stream and a light recycled content pyrolysis oil (r-pyoil) stream having a T50 of less than 400°F in a reformer to produce a reformate comprising r-pX.

[0004] In one aspect, the present technology concerns a method for producing recycled content para-xylene (r-pX), the method comprising: (a) distilling crude oil in at least one distillation column to produce at least one

naphtha stream having a T50 of less than 400°F; and (b) reforming at least a portion of the naphtha stream and a light recycled content pyrolysis oil (r-pyoil) stream having a T50 of less than 400°F in a reformer to produce a reformate comprising r-pX, wherein the naphtha stream and/or the light r-pyoil stream are optionally hydrotreated prior to the reforming (b).

[0005] In one aspect, the present technology concerns a method for producing a recycled content organic chemical compound (r-organic chemical compound), the method comprising: (a) introducing a recycled content reformate (r-reformate) stream into an aromatics complex, wherein the r-reformate stream is obtained by distilling crude oil in at least one distillation column to produce at least one naphtha stream having a T50 of less than 400°F, and reforming at least a portion of the naphtha stream and a light recycled content pyrolysis oil (r-pyoil) stream having a T50 of less than 400°F in a reformer to produce the r-reformate stream, wherein the naphtha stream and/or the light r-pyoil stream is optionally hydrotreated prior to the reforming; and (b) processing the r-reformate stream in the aromatics complex to provide an r-pX stream comprising at least 85 weight percent para-xylene.

[0006] In one aspect, the present technology concerns a method for producing a recycled content organic chemical compound (r-organic chemical compound), the method comprising: (a) introducing a stream of recycled content paraxylene (r-pX) into a terephthalic acid (TPA) production facility, wherein at least a portion of the r-pX is obtained by distilling crude oil in at least one distillation column to produce at least one naphtha stream having a T50 of less than 400°F, and reforming at least a portion of the naphtha stream and a light recycled content pyrolysis oil (r-pyoil) stream having a T50 of less than 400°F in a reformer to produce the r-reformate stream, wherein the naphtha stream and/or the light r-pyoil stream is optionally hydrotreated prior to the reforming, and processing at least a portion of the r-reformate stream in an aromatics complex to produce the r-pX; and (b) processing at least a portion of the r-pX in the

TPA production facility to provide recycled content purified terephthalic acid (r-PTA).

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a schematic block flow diagram illustrating the main processes/facilities in a system for providing recycled content organic chemical compounds, including r-paraxylene, r-terephthalic acid, and r-polyethylene terephthalate, according to various embodiments of the present invention;

[0008] FIG. 2 is a schematic block flow diagram illustrating the main steps/zones in a pyrolysis facility suitable for use in the system illustrated in FIG. 1;

[0009] FIG. 3 is a schematic block flow diagram illustrating the main steps/zones in a refinery suitable for use in the system illustrated in FIG. 1;

[00010] FIG. 4 is a schematic block flow diagram illustrating the main steps/zones in a refinery suitable for use in the system illustrated in FIG. 1, including integration with an NGL processing facility;

[00011] FIG. 5 is a schematic block flow diagram illustrating the main steps/zones in an aromatics complex suitable for use in the system illustrated in FIG. 1;

[00012] FIG. 6A is a block flow diagram illustrating the main steps of a process for making recycled content aromatics (r-aromatics) and recycled content paraxylene (r-paraxylene), and optionally, a recycled content organic chemical compound from the r-paraxylene, wherein the r-aromatics (and r-paraxylene and r-organic chemical compound) have physical content from one or more source materials; and

[00013] FIG. 6B is a block flow diagram illustrating the main steps of a process for making recycled content aromatics (r-aromatics) and recycled content paraxylene (r-paraxylene), and optionally, a recycled content organic chemical compound from the r-paraxylene, wherein the r-aromatics (and r-paraxylene and r-organic chemical compound) have credit-based recycled content from one or more source materials.

DETAILED DESCRIPTION

[00014] We have discovered a method for producing a recycled content organic chemical compound from hydrocarbon streams with recycled content derived from waste plastic. More specifically, hydrocarbon streams formed by the pyrolysis or cracking of waste plastic can be further

processed in a petroleum refinery and/or steam cracking facility to provide recycled content aromatics, which are further processed in an aromatics complex to provide purified streams of recycled content benzene (r-benzene), recycled content toluene (r-toluene), and recycled content xylene (r-xylene), including recycled content paraxylene (r-pX). All or a portion of the r-pX can then be further processed to form additional recycled content chemicals, such as recycled content terephthalic acid (r-TPA) and/or recycled content polyethylene terephthalate (r-PET). We have further discovered a method for catalytic reforming recycled content light pyrolysis oil, which can produce the recycled content aromatics.

[00015] In particular, we have discovered new methods and systems for producing paraxylene and organic chemical compounds formed by directly processing paraxylene or its derivatives, including, for example, organic chemical compounds such as terephthalic acid and polyethylene terephthalate. More specifically, we have discovered a process and system for producing paraxylene where recycled content from waste materials, such as waste plastic, are applied to paraxylene (or its derivatives) in a manner that promotes the recycling of waste plastic and provides paraxylene (or other organic chemical compounds) with substantial amounts of recycled content.

[00016] Turning initially to FIGS. 6A and 6B, paraxylene is formed by processing a predominantly aromatics stream in an aromatics complex to provide a stream including at least 85, at least 90, at least 92, at least 95, at least 97, or at least 99 weight percent paraxylene. The paraxylene stream can undergo one or more additional processing steps to provide at least one organic chemical compound derived from paraxylene. Examples of such organic chemical compounds include, but are not limited to, terephthalic acid, polymers such as polyethylene terephthalate, and other related organic chemical compounds.

[00017] As generally shown in FIGS. 6A and 6B, a stream of waste plastic processed in one or more conversion facilities may provide the aromatics

stream, which can be processed to form the paraxylene stream. The recycled content in the paraxylene stream can be physical and may directly originate from waste plastic or an intermediate hydrocarbon stream formed by processing waste plastic, and/or the recycled content may be credit based and can be applied to a target stream in the aromatics complex and/or chemical processing facilities.

[00018] The aromatics (or paraxylene or organic chemical compound) streams can have a total recycled content of at least 5, at least 10, at least 15, at least 20, at least 25, at least 30, at least 35, at least 40, at least 45, at least 50, at least 55, or at least 65 percent and/or 100 percent, or less than 99, less than 95, less than 90, less than 85, less than 80, less than 75, or less than 70 percent. Similarly, the r-TPA and/or r-PET or even the r-aromatics stream can have a recycled content of at least 5, at least 10, at least 15, at least 20, at least 25, at least 30, at least 35, at least 40, at least 45, at least 50, at least 55, or at least 65 percent and/or 100 percent, or less than 99, less than 95, less than 90, less than 85, less than 80, less than 75, or less than 70 percent. The recycled content in one or more of these streams can be physical recycled content, credit-based recycled content, or a combination of physical and credit-based recycled content.

[00019] Turning initially to FIG. 6A, in one embodiment or in combination with one or more embodiments mentioned herein, at least a portion of the recycled content in the aromatics and/or paraxylene stream (or in the organic chemical compound product stream) can be physical (direct) recycled content. This recycled content may originate from a waste plastic stream. The waste plastic stream is ultimately converted in one or more conversion facilities (e.g., a pyrolysis facility, a refinery, a steam cracking facility, and/or a molecular reforming facility and methanol-to-aromatics facility), which is processed (alone or with a non-recycled content aromatics stream) as described herein to provide an r-paraxylene stream. The r-paraxylene stream can then be further processed (along or in combination with a non-recycled content paraxylene stream) to provide a

recycled content organic chemical compound, including, but not limited to, recycled content terephthalic acid (r-TPA), recycled content polyethylene terephthalate (r-PET), and one or more additional recycled content organic chemical compounds (r-organic chemical compounds).

[00020] The amount of physical recycled content in the target product (e.g. composition, r-aromatics or r-paraxylene or r-organic chemical compound) can be determined by tracing the amount of waste plastic material processed along a chain of chemical pathway(s) and ending with the moiety or portion of the target product attributable to the waste plastic chemical pathway. As used herein, a moiety can be a portion the atoms and their structure of a target product and can also include the entire chemical structure of the target product and does not necessarily require the inclusion of a functional group. For example, a moiety of p-xylene can include the aromatic ring, a portion of the aromatic ring, the methyl groups, or the entire p-xylene molecule. The chemical pathway includes all chemical reactions and other processing steps (e.g., separations) between the starting materials (e.g., waste plastic) and the moiety in the target product attributable to the chemical pathway originating in waste plastics. For example, the chemical pathway for the r-aromatics can include pyrolysis, optionally refining and/or stream cracking, and/or molecular reforming and methanol synthesis and conversion. The chemical pathway for the r-paraxylene can further include processing in the aromatics complex, and the chemical pathway for the r-organic chemical compound may include a variety of additional steps, such as, for example, oxidation, polymerization, etc., depending on the specific r-organic chemical compound. A conversion factor may be associated with each step along the chemical pathway. The conversion factors account for the amount of the recycled content diverted or lost at each step along the chemical pathway. For example, the conversion factors can account for the conversion, yield, and/or selectivity of the chemical reactions along the chemical pathway.

[00021] The amount of credit-based recycled content in a target product (e.g. compositions, r-aromatics or r-paraxylene or r-organic chemical compounds) can be determined by calculating the mass weight percent of a target moiety in a target product and attributing a recycle content credit to the target product in any amount up to the mass weight percent of the target moiety in the target product as a maximum. The credit based recycle content that is eligible to be applied to the target product is determined by tracing the waste plastic material along a chain of chemical pathway(s) and ending with the same moiety as target moiety in the target product. Thus, the credit based recycle content can be applied to a variety of different target products having the same moiety even though the products are made by entirely different chemical pathways provided that the credit applied is obtained from waste plastic and the waste plastic ultimately undergoes at least one chemical pathway originating from waste plastic and ending in the target moiety. For example, if a recycle content credit is obtained from waste plastic and booked into a recycle content inventory, and there exists chemical pathways at the facility capable of processing the waste plastic through to a target moiety such as p-xylene (e.g. a pyrolysis reactor effluent to a crude distillation column to a hydrotreater to a reformer to an aromatics complex that isolates p-xylene), the recycle content credit is then a type eligible to apply to any p-xylene molecule made by any chemical pathway, including the one existing at the facility and/or to the p-xylene portion of a pyrolysis gasoline stream composition obtained from a steam cracker and gasoline fractionator. As with physical recycled content, a conversion factor may or may not be associated with each step along the chemical pathway. Additional details on credit-based recycled content are provided below.

[00022] The amount of recycled content applied to the r-aromatics (or r-paraxylene or r-organic chemical compound) can be determined using one of variety of methods for quantifying, tracking, and allocating recycled content among various materials in various processes. One suitable

method, known as "mass balance," quantifies, tracks, and allocates recycled content based on the mass of the recycled content in the process. In certain embodiments, the method of quantifying, tracking, and allocating recycled content is overseen by a certification entity that confirms the accuracy of the method and provides certification for the application of recycled content to the r-aromatics (or r-paraxylene or r-organic chemical compound).

[00023] Turning now to FIG. 6B, one embodiment where the r-organic chemical compound (or r-paraxylene) includes credit-based recycled content, is provided. Recycled content credits from waste plastic are attributed to one or more streams within the facility. For example, the recycled content credits derived from waste plastics can be attributed to the aromatics stream fed to the aromatics complex, or to any of the products separated and isolated in the aromatics complex, such as to the paraxylene stream. Alternatively, or in addition, recycled content credits obtained from one or more intermediate streams within the conversion facility and/or aromatics complex can also be attributed to one or more products, such as paraxylene, within the facility, depending on the specific configuration of the system. Further, recycled content credits from one or more of these streams may also be attributed to the organic chemical compound stream, as shown in FIG. 6B.

[00024] As such, the waste plastic stream, or the r-aromatics stream and r-paraxylene streams (and any recycled content intermediate streams not shown in FIG. 6B) not made at the facility or purchased or acquired, can each act as a "source material" of recycled content credits. The aromatics fed to the aromatics complex, the paraxylene product or any other products separated and/or isolated from the aromatics complex, the paraxylene transferred (including sales) or fed to the chemical processing facility, any intermediate streams not shown, and even the organic chemical compound, can each act as a target product to which the recycled content credits are attributed. In one embodiment or in

combination with any embodiment mentioned herein, the source material has physical recycled content and the target product has less than 100 percent physical recycled content. For example, the source material can have at least 10, at least 25, at least 50, at least 75, at least 90, at least 99, or 100 percent physical recycled content and/or the target product can have less than 100, less than 99, less than 90, less than 75, less than 50, less than 25, less than 10, less than 1 percent, or no physical recycled content.

[00025] The ability to attribute recycled content credits from a source material to a target product removes the co-location requirement between the facility making the source material (with physical recycled content) and the facility making the aromatics or products receiving recycle content value (e.g. paraxylene or organic chemical compound). This allows a chemical recycling facility/site in one location to process waste material into one or more recycled content source materials and then apply recycled content credits from those source materials to one or more target products being processed in existing commercial facilities located remotely from the chemical recycling facility/site, optionally within the same Family of Entities, or to associate a recycle content value with a product that is transferred to another facility, optionally owned by a different entity that can deposit the recycle content credit into its recycle content inventory one the product is receiving, purchased, or otherwise transferred. Further, the use of recycled content credits allows different entities to produce the source material and the aromatics (or paraxylene or organic chemical compound). This allows efficient use of existing commercial assets to produce the aromatics (or paraxylene or organic chemical compound). In one or more embodiments, the source material is made at a facility/site that is at least 0.1, at least 0.5, at least 1, at least 5, at least 10, at least 50, at least 100, at least 500, or at least 1000 miles from the facility/site where the target product is used to make the aromatics (or paraxylene or organic chemical compound).

[00026] The attributing of recycled content credits from the source material (e.g., the r-aromatics from the conversion facility) to the target product (e.g., an aromatics stream fed to an aromatics complex) can be accomplished by transferring recycled content credits directly from the source material to the target product. Alternatively, as shown in FIG. 6B, recycled content credits can be applied from any of the waste plastic, r-aromatics, and r-paraxylene (when present) to the aromatics, paraxylene, or organic chemical compound via a recycled content inventory.

[00027] When a recycled content inventory is used, recycled content credits from the source material having physical recycled content (e.g., the waste plastic, the r-aromatics, and optionally the r-paraxylene shown in FIG. 6B) are booked into the recycled content inventory. The recycled content inventory can also contain recycled content credits from other sources and from other time periods. In one embodiment, recycled content credits in the recycled content inventory correspond to a moiety, and the recycle content credit is applied or assigned to the same a target products containing a target moiety, and the target moiety is either (i) not chemically traceable through chemical pathways used to for generating the recycle content credit or (ii) is chemically traceable through chemical pathways used for generating the recycle content credit. Chemical traceability is achieved when atoms from a source material such as waste plastic can be theoretically traced to one or more atoms in the target moiety of a target product through each chemical pathway to obtain that atom(s) in the target moiety.

[00028] In some embodiments, there may be a periodic (e.g., annual or semi-annual) reconciliation between waste plastic credits deposited in the recycled content inventory and the mass of waste plastic processed. Such reconciliations may be performed by an appropriate entity at an interval consistent with rules of the certification system in which the producer is participating.

[00029] In one embodiment, once recycled content credits have been attributed to the target product (e.g., the aromatics stream, the paraxylene stream, or any intermediate stream not shown), the amount of the credit-based recycled content allocated to the organic chemical compound (e.g., TPA, PET, or other organic chemical compound) is calculated by the mass proportion of atoms in the target product that are chemically traceable to the source material. In another embodiment, a conversion factor can be associated with each step along the chemical pathway of the credit-based recycled content. The conversion factors account for the amount of the recycled content diverted or lost at each step along the chemical pathway. For example, the conversion factors can account for the conversion, yield, and/or selectivity of the chemical reactions along the chemical pathway. However, if desired, the amount of recycle content applied to a target product can be more than the mass proportion of the target moiety chemically traceable to the waste plastic source material. The target product can receive up to 100% recycle content even though the mass proportion of atoms in the target moiety that is chemically traceable to a recycle source material, such as mixed plastic waste stream, is less than 100%. For example, if the target moiety in a product represents only 30 wt.% of all atoms in a target product that are chemically traceable to a mixed plastic waste stream, the target product can nevertheless receive more than 30% recycle content value, up to 100% if desired. While such application would violate chemical traceability for the full value of the amount of recycle content in a target product back to a waste plastic source, the particular amount of recycle content value applied to a target product will depend on the rules of a certification system that the producer participates in.

[00030] As with the physical recycled content, the amount of credit-based recycled content applied to the r-aromatics (or r-paraxylene or r-organic chemical compound) can be determined using one of variety of methods, such as mass balance, for quantifying, tracing, and allocating recycled

content among various products in various processes. In certain embodiments the method of quantifying, tracing, and allocating recycled content is overseen by a certification entity that confirms the accuracy of the method and provides certification for the application of recycled content to the r-aromatics (or r-paraxylene or r-organic chemical compound).

[00031] The r-aromatics (or r-paraxylene or r-organic chemical compound) can have 25 to 90, 40 to 80, or 55 to 65 percent credit-based recycled content and less than 50, less than 25, less than 10, less than 5, or less than 1 percent physical recycled content. In certain embodiments, the r-aromatics (or r-paraxylene or r-organic chemical compound) can have at least 10, at least 25, at least 50, or at least 65 percent and/or not more than 90, not more than 80, or not more than 75 percent credit-based recycled content from one or more of the r-aromatics and/or r-paraxylene, individually.

[00032] In one or more embodiments, the recycled content of the r-aromatics (or r-paraxylene or r-organic chemical compound) can include both physical recycled content and credit-based recycled content. For example, the r-aromatics (or r-paraxylene or r-organic chemical compound) can have at least 10, at least 20, at least 30, at least 40, or at least 50 percent physical recycled content and at least 10, at least 20, at least 30, at least 40, or at least 50 percent credit-based recycled content. As used herein, the term “total recycled content” refers to the cumulative amount of physical recycled content and credit-based recycled content from all sources.

[00033] Turning now to FIG. 1, a process and facility for use in forming a recycled content organic chemical compound is provided. Specifically, the system illustrated in FIG. 1 can form recycled content paraxylene (r-pX) from one or more streams having recycled content from waste plastic. The system shown in FIG. 1 includes a pyrolysis facility, a refinery, a steam cracking facility, and an aromatics complex. Optionally, at least a

portion of the r-pX can be oxidized to form recycled content terephthalic acid (r-TPA) in a TPA production facility and at least a portion of the r-TPA can be polymerized to form recycled content polyethylene terephthalate (r-PET). The r-pX formed as described herein may be used in other applications not illustrated in FIG. 1.

[00034] The facility shown in FIG. 1 can be a chemical recycling facility. Chemical recycling facilities are not the same as mechanical recycling facilities. As used herein, the terms "mechanical recycling" and "physical recycling" refer to a recycling process that includes a step of melting waste plastic and forming the molten plastic into a new intermediate product (e.g., pellets or sheets) and/or a new end product (e.g., bottles). Generally, mechanical recycling does not substantially change the chemical structure of the plastic being recycled. The chemical recycling facilities described herein may be configured to receive and process waste streams from and/or that are not typically processable by a mechanical recycling facility.

[00035] In one embodiment or in combination with any embodiments mentioned herein, at least two, at least three, at least four, at least five, or all of the pyrolysis facility, the refinery, the steam cracking facility, the aromatics complex, and the optional TPA production facility and the optional PET facility may be co-located. As used herein, the term "co-located" refers to the characteristic of at least two objects being situated on a common physical site, and/or within 5, within 3, within 1, within 0.75, within 0.5, or within 0.25 miles of each other, measured as a straight-line distance between two designated points.

[00036] When two or more facilities are co-located, the facilities may be integrated in one or more ways. Examples of integration include, but are not limited to, heat integration, utility integration, waste-water integration, mass flow integration via conduits, office space, cafeterias, integration of plant management, IT department, maintenance department, and sharing of common equipment and parts, such as seals, gaskets, and the like.

[00037] Additionally, one or more, two or more, three or more, four or more, five, or all, of the pyrolysis facility, the refinery, the steam cracking facility, the aromatics complex, the TPA production facility, and the PET production facility may be commercial-scale facilities. For example, in one embodiment or in combination with any embodiments mentioned herein, one or more of these facilities/steps can accept one or more feed streams at a combined average annual feed rate of at least 500, at least 1000, at least 1500, at least 2000, at least 5000, at least 10,000, at least 50,000, or at least 100,000 pounds per hour, averaged over one year. Further, one or more of the facilities can produce at least one recycled content product streams at an average annual rate of at least 500, or at least 1000, at least 1500, at least 2000, at least 2500, at least 5000, at least 10,000, at least 50,000, or at least 75,000 pounds per hour, averaged over one year. When more than one r-product stream is produced, these rates can apply to the combined rate of all r-products.

[00038] One or more, two or more, three or more, four or more, five, or all, of the pyrolysis facility, the refinery, the steam cracking facility, the aromatics complex, the TPA production facility, and the PET production facility can be operated in a continuous manner. For example, each of the steps or processes within each of the facilities and/or the process amongst the facilities may be operated continuously and may not include batch or semi-batch operation. In one embodiment or in combination with any embodiments mentioned herein, at least a portion of one or more of the facilities may be operated in a batch or semi-batch manner, but the operation amongst the facilities may be continuous overall.

[00039] As shown in FIG. 1, mixed waste plastic can be introduced into the pyrolysis facility, wherein it may be pyrolyzed to form at least one recycled content pyrolysis effluent stream. In one embodiment or in combination with any embodiments mentioned herein, the system shown in FIG. 1 may also include a plastics processing facility for separating a stream of mixed plastic waste into a predominantly polyolefin (PO) waste plastic and a

predominantly non-PO waste plastic, which typically includes waste plastics such as polyethylene terephthalate (PET), polyvinyl chloride (PVC), and others. In addition, when present, the plastics processing facility can also remove other non-plastic components, such as glass, metals, dirt, sand, and cardboard from the incoming waste stream.

[00040] Turning now to FIG. 2, a schematic diagram of the main steps/zones of a pyrolysis facility as shown in FIG. 1 are provided. As shown in FIG. 2, the waste plastic stream can be introduced into a pyrolysis facility and pyrolyzed in at least one pyrolysis reactor. The pyrolysis reaction involves chemical and thermal decomposition of the waste plastic introduced into the reactor. Although all pyrolysis may be generally characterized by a reaction environment that is substantially free of oxygen, pyrolysis processes may be further defined by other parameters such as the pyrolysis reaction temperature within the reactor, the residence time in the pyrolysis reactor, the reactor type, the pressure within the pyrolysis reactor, and the presence or absence of pyrolysis catalysts.

[00041] The feed to the pyrolysis reactor can comprise, consists essentially of, or consists of waste plastic, and the feed stream can have a number average molecular weight (Mn) of at least 3000, at least 4000, at least 5000, or at least 6000 g/mole. If the feed to the pyrolysis reactor contains a mixture of components, the Mn of the pyrolysis feed is the average Mn of all feed components, based on the weight of the individual feed components. The waste plastic in the feed to the pyrolysis reactor can include post-consumer waste plastic, post-industrial waste plastic, or combinations thereof. In certain embodiments, the feed to the pyrolysis reactor comprises less than 5, less than 2, less than 1, less than 0.5, or about 0.0 weight percent coal and/or biomass (e.g., lignocellulosic waste, switchgrass, fats and oils derived from animals, fats and oils derived from plants, etc.). The feed to the pyrolysis reaction can also comprise less than 5, less than 2, less than 1, or less than 0.5, or about 0.0 weight

percent of a co-feed stream, including steam and/or sulfur-containing co-feed streams. In other cases, steam fed to the pyrolysis reactor can be present in amounts of up to 50 weight percent.

[00042] The pyrolysis reaction can involve heating and converting the waste plastic feedstock in an atmosphere that is substantially free of oxygen or in an atmosphere that contains less molecular oxygen relative to ambient air. For example, the atmosphere within the pyrolysis reactor may comprise not more than 5, not more than 4, not more than 3, not more than 2, not more than 1, or not more than 0.5 weight percent of molecular oxygen.

[00043] The pyrolysis reaction in the reactor can be thermal pyrolysis, which is carried out in the absence of a catalyst, or catalytic pyrolysis, which is carried out in the presence of a catalyst. When a catalyst is used, the catalyst can be homogenous or heterogeneous and may include, for example, certain types of zeolites and other mesostructured catalysts.

[00044] The pyrolysis reactor may have any suitable design and can comprise a film reactor, a screw extruder, a tubular reactor, a stirred tank reactor, a riser reactor, a fixed bed reactor, a fluidized bed reactor, a rotary kiln, a vacuum reactor, a microwave reactor, or an autoclave. The reactor may also utilize a feed gas and/or lift gas for facilitating the introduction of the feed into the pyrolysis reactor. The feed gas and/or lift gas can comprise nitrogen and can comprise less than 5, less than 2, less than 1, or less than 0.5, or about 0.0 weight percent of steam and/or sulfur-containing compounds. The feed and/or lift can also include light hydrocarbons, such a methane, or hydrogen, and these gases may be used alone or in combination with steam.

[00045] As shown in FIG. 2, a stream of recycled content pyrolysis effluent (r-pyrolysis effluent) removed from the reactor can be separated in a separation zone to provide a recycled content pyrolysis vapor (r-pyrolysis vapor) stream and a recycled content pyrolysis residue (r-pyrolysis residue) stream. The r-pyrolysis vapor can include a range of hydrocarbon materials and may comprise both recycled content pyrolysis gas (r-pygas)

and recycled content pyrolysis oil (r-pyoil). In some embodiments, the pyrolysis facility may include an additional separation zone, as shown in FIG. 2, to separate the r-pyoil and r-pygas into separate streams. Alternatively, the entire stream of r-pyrolysis vapor may be withdrawn from the pyrolysis facility and routed to one or more downstream processing facilities.

[00046] Referring again to FIG. 1, at least a portion of the r-pyoil and/or r-pygas (or r-pyrolysis vapor) can be introduced into a refinery, wherein it can undergo one or more processing steps to provide at least a stream of recycled content light gas (r-light gas) and/or a stream of recycled content naphtha (r-naphtha), as well as other recycled content hydrocarbon streams, such as recycled content reformate (r-reformate). Examples of suitable processing steps include, but are not limited to, distillation or other separation steps as well as chemical processing such as thermal and/or catalytic cracking or other reactions such as catalytic reforming and isomerization.

[00047] Turning now to FIG. 3, a schematic diagram of the main steps or zones in a refining facility, or refinery, suitable for processing at least one hydrocarbon stream including recycled content derived from waste plastic is provided. It should be understood that other processing steps may exist and/or other recycled content hydrocarbon streams may be produced in the refinery shown in FIG. 3. The steps, zones, and process streams illustrated in FIG. 3 are provided for simplicity and not intended to exclude other steps, zones, or process streams not shown.

[00048] As shown in FIG. 3, a stream of crude oil may be introduced into an atmospheric distillation unit (ADU) and separated in at least one distillation column to provide several hydrocarbon fractions having specified cut points. As used herein, the term “cut point” refers to the range of temperatures over which a specified petroleum fraction boils. The lower value in a boiling point range is the initial boiling point (IBP) temperature for that specified fraction and the higher value is the end point (EP)

temperature for that specified fraction. Cut points are often used to identify specific streams or fractions within and/or produced by the refinery.

[00049] In addition to a stream of crude oil, the refinery shown in FIG. 3 can also process a stream of r-pyoil introduced into the ADU. In one embodiment or in combination with any embodiments mentioned herein, the r-pyoil may originate from a pyrolysis reactor process as discussed previously with respect to FIG. 1. Before introduction to the refinery processes, the r-pyoil (comprising predominantly C6-C40 hydrocarbons) may be separated into a light pyoil stream (comprising predominantly C6-C10 hydrocarbons) and a heavy pyoil stream (comprising predominantly C10-C40 hydrocarbons). In such embodiments, the heavy pyoil stream may be introduced into the ADU for further separation, while the light pyoil stream may be introduced intro other downstream refinery processes, such as reforming and/or steam cracking. It should be understood that the light pyoil stream and heavy pyoil stream may comprise recycled content, as these streams are derived from the r-pyoil stream. In one embodiment or in combination with any embodiments mentioned herein, the light pyoil (light r-pyoil) stream can have a T50 of less than 400°F (204°C), or 180 °F to 380 °F (82 °C to 193 °C). The ratio of the mass flow rate of r-pyoil (unseparated or as heavy pyoil) introduced into the ADU to the mass flow rate of petroleum oil introduced into the ADU can be at least 1:100, at least 1:50, at least 1:25, or at least 1:10 and/or not more than 1:1, not more than 1:2, not more than 1:5, or not more than 1:10. Alternatively, when the r-pyoil is not introduced into the ADU, the feed to the atmospheric distillation column may include less than 1000, less than 500, less than 250, less than 100, less than 75, less than 50, less than 30, or less than 20 parts per million (ppm) by weight of r-pyoil, or it can include no r-pyoil. Additionally, or in the alternative, a stream of recycled content pyrolysis vapor (r-pyrolysis vapor) and/or a stream of recycled content pyrolysis residue (r-pyrolysis residue) could be introduced into the ADU (not shown), alone or

in combination with one another and/or r-pyoil, and may be further separated as described herein.

[00050] The ADU separates the feed stock (e.g., crude oil) in at least one distillation column into multiple hydrocarbon streams, or fractions. As shown in FIG. 3, these fractions include, but are not limited to, light (ADU) gas, naphtha (which can be further separated into light naphtha and heavy naphtha, either in the ADU or downstream of the ADU), distillate (fuel/kerosene/diesel oil), gas oil (called atmospheric gas oil, ADU gas oil, or AGO), and residue (generally the ADU bottoms). In one embodiment or in combination with any embodiments mentioned herein, the naphtha stream(s) produced by the ADU can have a T50 of less than 400°F (204°C), or 180 °F to 380 °F (82 °C to 193 °C). When the ADU processes at least one recycled content feedstock, such as r-pyoil, each of the products formed by the ADU may include recycled content. Thus, the ADU may provide recycled content light ADU gas (r-light gas), recycled content naphtha (r-naphtha) (including recycled content light naphtha and recycled content heavy naphtha), recycled content distillate (r-distillate) (including recycled content fuel, recycled content kerosene, and recycled content diesel oil), recycled content atmospheric gas oil (r-AGO), and recycled content atmospheric residue (r-atmospheric resid). The mass flow rate of each stream, as well as its mass or volume in proportion to other streams depends on the operation of the ADU as well as the properties of the feedstocks being processed. As mentioned previously, other hydrocarbon streams can be produced from the ADU, but are not shown here for simplicity.

[00051] The ADU comprises at least one distillation column operated at or near atmospheric pressure. Additionally, the ADU may include other equipment such as desalters, side strippers, and reflux drums/accumulators, as well as various pumps, heat exchangers, and other auxiliary equipment needed to operate the unit.

[00052] Referring again to FIG. 3, the overhead gas stream withdrawn from the ADU (ADU Gas) comprises predominantly C6 and lighter components. In one embodiment or in combination with any embodiments mentioned herein, this predominantly gas stream withdrawn from the ADU can include at least 55, at least 60, at least 65, at least 70, at least 75, at least 80, at least 85, at least 90, or at least 95 weight percent of C6 and lighter components. In one embodiment or in combination with any embodiments mentioned herein, this stream may also include at least 25, at least 30, or at least 35 weight percent of C1 and lighter components, as well as small amounts of sulfur-containing compounds, chlorine-containing compounds, and/or nitrogen-containing compounds. As used herein, the term "C1 and lighter" components refers to methane (C1) and compounds having a lower boiling point than methane, at standard conditions. Examples of components lighter than C1 include, but are not limited to hydrogen (H2), carbon monoxide (CO), and nitrogen (N2).

[00053] The overhead gas stream from the ADU may be processed in a saturated gas plant (not shown), wherein it can be separated into two or more streams via one or more distillation steps. For example, in one embodiment or in combination with any embodiments mentioned herein, the overhead gas stream may be separated to remove most of the C1 and lighter components in a demethanizer column, and/or may be processed to remove most of the C5 and heavier components in a debutanizer column. Other columns (e.g., deethanizer, depropanizer, etc.) may also be used to form various product streams (e.g., ethane, propane, etc.) depending on the configuration of the refinery and the saturated gas plant. The saturated gas plant can also include one or more treatment steps for the removal of nitrogen- and/or sulfur-containing components.

[00054] As also shown in FIG. 3, streams of recycled content naphtha (r-naphtha) and recycled content distillate (r-distillate) may be withdrawn from the ADU and can be sent to one or more downstream locations for additional processing, storage, and/or use. Although FIG. 3 depicts

separate light naphtha (predominantly C6 and lighter) and heavy naphtha (predominantly C6-C10) streams derived from the ADU, in one embodiment or in combination with any embodiments mentioned herein, these separate streams may exit the ADU as a single r-naphtha steam. The r-naphtha stream may then be fed to a separator (not shown) to thereby produce the separate light naphtha and heavy naphtha streams. One or more of these streams may also be further processed to remove components such as sulfur-containing compounds, chlorine-containing compounds, and/or nitrogen before further processing and/or use, as described in greater detail below.

[00055] The heaviest stream withdrawn from the ADU (ADU Bottoms) is a stream of recycled content atmospheric resid (r-atmospheric resid). In some cases, the r-atmospheric resid may be sent directly to a fluidized catalytic cracker (FCC), while in other cases, it may be introduced into a vacuum distillation unit (VDU). In the VDU, further separation of various hydrocarbon fractions can be performed in a vacuum distillation column operated at pressures below atmospheric pressure. For example, in one embodiment or in combination with any embodiments mentioned herein, the overhead pressure of the vacuum distillation column can be less than 100, less than 75, less than 50, less than 40, or less than 10 mm Hg. Distilling the r-atmospheric resid at low pressure permits further recovery of lighter hydrocarbon components without cracking. The VDU provides product streams similar to the ADU, and when it processes a recycled content feedstock, provides recycled content products. Examples of such products include, but are not limited to, recycled content light vacuum gas oil (r-LVGO), recycled content heavy vacuum gas oil (r-HVGO), and recycled content vacuum resid (r-vacuum resid).

[00056] In one embodiment or in combination with any embodiments mentioned herein, at least a portion of one or more of the heavier hydrocarbon fractions (e.g., heavier than distillate) from the ADU and/or VDU can be sent to a gas oil cracker. Such heavier hydrocarbon fractions

can have a median boiling point (T50) greater than 375, greater than 400, greater than 500, greater than 600, greater than 700, greater than 800, or greater than 900°F. One or more of these heavy hydrocarbon fractions can comprise at least 85, at least 90, at least 95, at least 97, or at least 99 weight percent of C10,C15, C20, or C25 and heavier components. Examples of these streams as shown in FIG. 3 can include, but are not limited to, r-AGO, r-atmospheric resid, r-vacuum resid, r-LVGO, and r-HVGO.

[00057] As mentioned previously, at least a portion of the r-atmospheric resid may be introduced into the FCC, particularly when the refinery does not include a VDU. As shown in FIG. 3, when the refinery has a VDU, at least a portion of the r-HVGO may be introduced into a hydrocracker (HDC). The r-LVGO can be fed to the FCC along with at least a portion of the r-AGO. Depending on the specific configuration of the refinery, other processing schemes are possible that fall within the scope of the present technology.

[00058] The gas oil cracker can be any processing unit or zone that reduces the molecular weight of a heavy hydrocarbon feedstock to provide one or more lighter hydrocarbon products. The gas oil cracker may employ thermal and/or catalytic cracking and can include other equipment such as compressors, distillation columns, heat exchangers, and other equipment necessary to provide the cracked product streams. Examples of gas oil crackers illustrated in FIG. 3 include a fluidized catalytic cracker (FCC) and a hydrocracker (HDC).

[00059] In one embodiment or in combination with any embodiments mentioned herein, at least one of the heavy hydrocarbon streams introduced into and/or at least one of the cracked hydrocarbon streams removed from one or more of the gas oil crackers (e.g., hydrocracker, coker, and/or FCC) may be treated with hydrogen to remove all or a portion of one or more components such as sulfur-containing compounds (e.g., hydrogen sulfide, mercaptans, etc.), nitrogen-containing compounds,

metals (e.g., vanadium, mercury, etc.), and/or chlorine-containing compounds and/or to saturate at least a portion of the olefinic and/or aromatic compounds in the stream. As shown in FIG. 3, for example, at least a portion of the r-AGO stream and/or at least a portion of the r-LVGO stream may be hydrotreated before introduction into the FCC. Specific locations of the hydrotreating steps can vary and may depend on the specific refinery configuration, as well as the final product specifications for sulfur, nitrogen, metal, and aromatics/olefins.

[00060] Additionally, or alternatively, one or more processing steps may be present in the refinery to remove chlorine-containing compounds. The total content of chlorine-containing compounds in the r-pyoil (or combined r-pyoil and crude oil) stream can be at least 20, at least 50, at least 75, at least 100 ppm by weight and/or not more than 500, not more than 350, not more than 200, or not more than 100 ppm by weight.

[00061] Alternatively, or in addition, at least a portion of the cracking can be performed in the presence of hydrogen (e.g., in a hydrocracker) so that removal of components such as nitrogen-, chlorine-, and sulfur-containing components (and optionally metals), may be performed at the same time as the cracking reaction. When cracking and hydrogenation occur simultaneously, the saturation of olefinic hydrocarbons may also take place such that the amount of or olefins in the hydrocracker product stream is not more than 20, not more than 15, not more than 10, or not more than 5 weight percent. However, aromatics may remain such that the amount of aromatics in the stream withdrawn from the hydrocracker may be at least 1, at least 5, at least 10, at least 20, or at least 25 and/or not more than 50, not more than 40, or not more than 35 weight percent. If cracking is performed within a hydrocracker or the streams to be cracked have been hydrotreated prior to cracking, further downstream hydrotreating is optional.

[00062] In one embodiment or in combination with any embodiments mentioned herein, one or more recycled content cracked hydrocarbon (r-

cracked hydrocarbon) streams from the gas oil cracker may be further cracked in another gas oil cracker to provide additional recycled content cracked hydrocarbon (r-cracked hydrocarbon) streams. For example, as shown in FIG. 3, at least a portion of the r-LVGO from the VDU and/or the r-hydrocracker distillate (r-HDC) from the hydrocracker may be introduced into the FCC. Additionally, or in the alternative, at least a portion of a stream of recycled content coker gas oil (r-CGO) from the coker (not shown) can be introduced into the FCC for further cracking to form r-light gas and/or r-naphtha. Other processing schemes are possible depending on the specific equipment and configuration of the refinery.

[00063] In one embodiment or in combination with any embodiments mentioned herein, a stream of r-pyoil and/or waste plastic can be directly introduced into one or more gas oil cracker units within the refinery. Gas oil crackers may be operated at temperatures of at least 350°F, at least 400°F, at least 450°F, at least 500°F, at least 550°F, or at least 600°F and/or not more than 1200°F, not more than 1150°C, not more than 1100°F, not more than 1050°F, not more than 1000°F, not more than 900°F, or not more than 800°F. Gas oil crackers may be operated at or near atmospheric pressure (e.g., at a pressure of less than 5 psig, less than 2 psig, or 1 psig) or may be operated at elevated pressure (e.g., at a pressure of at least 5 psig, at least 10 psig, at least 25 psig, at least 50 psig, at least 100 psig, at least 250 psig, at least 500 psig, or at least 750 psig.) Additionally, the cracking in gas oil crackers may be carried with or without a catalyst, and it may or may not be conducted in the presence of hydrogen and/or steam. Examples of gas oil crackers include, but are not limited to, FCCs, cokers, and hydrocrackers.

[00064] For example, a stream of r-pyoil and/or waste plastic may be directly fed into at least one (at least two, or each) of a coker, a hydrocracker, and an FCC. These streams may be co-fed with one or more other hydrocarbon streams, which may or may not include recycled content. For example, waste plastic fed to the FCC may be co-fed with r-

AGO, r-LVGO, r-CGO, and/or r-HDC distillate. One or more of the gas oil and/or distillate streams fed to the gas oil cracker may also include non-recycled content, particularly if no r-pyoil (or other r-pyrolysis stream) is fed to the ADU.

[00065] When waste plastic is fed to one of these gas oil crackers, the waste plastic may be liquified mixed plastic waste formed by heating the waste plastic to at least partially melt it and/or by combining waste plastic with at least one solvent such as gas oil, r-gas oil, and/or r-pyoil. When combined with a solvent, the waste plastic may be dissolved or it may be in the form of a slurry. In one embodiment or in combination with any embodiments mentioned herein, the waste plastic introduced into the refinery may not have been separated (e.g., it may be mixed plastic waste), while in other cases, it may have undergone at least one separation step so that the waste plastic comprises predominantly polyolefin (PO) waste plastic. In such cases, the waste plastic may include at least 55, at least 60, at least 65, at least 70, at least 75, at least 80, at least 85, at least 90, at least 95, or at least 99 weight percent of PO waste plastic, based on the total weight of the stream.

[00066] In one embodiment or in combination with any embodiments mentioned herein, at least a portion of a recycled content effluent (r-effluent) stream from the FCC, hydrocracker, and/or coker reaction vessels may be separated in at least one gas plant (not shown) in fluid communication with one or more of these crackers.

[00067] In one embodiment or in combination with any embodiments mentioned herein, the streams exiting the gas oil cracker can comprise a recycled content naphtha (r-naphtha) stream. The r-naphtha stream comprises at least 20, at least 25, at least 30, at least 35, at least 40, at least 45, or at least 50 weight percent and/or not more than 85, not more than 80, not more than 75, not more than 70, not more than 65, or not more than 60 weight percent of recycled content benzene, recycled content toluene, and recycled content xylenes (r-BTX). In one

embodiment or in combination with any embodiments mentioned herein, the r-naphtha can also include at least 5, at least 10, or at least 15 weight percent and/or not more than 45, not more than 35, not more than 30, or not more than 25 weight percent of recycled content C9 to C12 aromatics and/or recycled content C6 and heavier cyclic hydrocarbons (r-C6+ cyclic hydrocarbons).

[00068] In one embodiment or in combination with any embodiments mentioned herein, the r-BTX in the r-naphtha can include at least 25, at least 30, at least 35, at least 40, or at least 45 weight percent and/or not more than 75, not more than 70, not more than 65, not more than 60, not more than 55, or not more than 50 weight percent of benzene, and/or at least 15, at least 20, at least 25, or at least 30 weight percent and/or not more than 65, not more than 60, not more than 55, not more than 50, not more than 45, not more than 40, or not more than 35 weight percent of toluene. Additionally, or in the alternative, the r-BTX in the r-naphtha can include at least 5, at least 10, at least 15, or at least 20 weight percent and/or not more than 50, not more than 45, not more than 35, not more than 30, or not more than 25 weight percent of mixed xylenes, including ortho-xylene (oX), meta-xylene (mX), and para-xylene (pX). At least a portion of the benzene, toluene, and/or xylenes in the r-BTX can comprise recycled content benzene, recycled content toluene, and/or recycled content xylenes, while, in other cases, at least a portion of the benzene, toluene, and/or xylenes may include non-recycled content.

[00069] Referring again to FIG. 3, at least a portion of the recycled content naphtha (r-naphtha) comprising a heavy naphtha cut from the ADU, or from one or more of the cracker facilities (e.g., the FCC, steam cracker, or hydrocracker), or any combination thereof, can be fed to a catalytic reformer, where the naphtha is reformed into a reformate stream comprising recycled content reformate (r-reformate).

[00070] In one embodiment or in combination with any embodiments mentioned herein, at least a portion of a recycled content pyrolysis oil (r-

pyoil) stream can be fed to a reformer in a similar manner as the r-naphtha, where the r-pyoil is reformed into a reformate stream. The r-pyoil stream fed to the reformer may comprise light pyoil (C6-C10), for example, produced from the separation of the r-pyoil into at least the light pyoil (C6-10) and heavy pyoil (C10-C40). As used herein, the terms "reformer" or "catalytic reformer" refer to a process or facility in which a feedstock comprising predominantly C6-C10 alkanes is converted to a reformate comprising branched hydrocarbons and/or cyclic hydrocarbons in the presence of a catalyst. Exemplary catalysts include platinum and/or rhenium, although other catalysts may be used. As shown in FIG. 3, the reformer may be a refinery catalytic reforming unit.

[00071] Prior to reforming, at least a portion of the r-pyoil stream and/or r-naphtha stream may undergo hydrotreating and/or nitrogen removal process, as shown in FIG. 3. Nitrogen-containing compounds present in the reformer feedstock can effectively poison the reformer catalyst, thereby requiring more frequent regeneration and/or replacement of the catalyst. Thus, the nitrogen removal process can remove organic nitrogen compounds (i.e., nitrogen-containing compounds) from the reformer feedstock to thereby produce a nitrogen-depleted product stream that can be used as a feedstock to the reformer, either alone or in combination with at least a portion of one or more other naphtha and/or r-naphtha containing process streams, as described herein. The process may include one or more adsorption and/or reaction steps, for example using one or more adsorbent clays, zeolites (e.g., H-form (acidic) zeolites, metal-containing (sodium, potassium, etc.) zeolites), molecular sieve, resins (e.g., acidic resins), alumina, silica, active carbon, modified alumina (i.e., modified with other metals), modified silica (i.e., modified with other metals), silico-aluminates, silica-alumina-phosphate oxides (SAPOs), and/or metal organic framework (MOFs), which can capture, convert, and/or separate the nitrogen compounds or nitrogen atoms from the reformer feedstock stream(s). The nitrogen-depleted product stream may

comprise less than 5, less than 2, less than 1, less than 0.5, or less than 0.1 ppm nitrogen (N) content. Although FIG. 3 depicts the r-pyoil stream being combined with one or more other streams prior to hydrotreating and/or nitrogen removal, it should be understood that the r-pyoil stream and one or more other streams may alternatively be separately hydrotreated and/or undergo nitrogen removal.

[00072] Whether or not the reformer feedstock (or the individual r-naphtha containing streams combined with the feedstock) undergoes hydrotreating and/or separate nitrogen removal, as well as where the hydrotreating process is located, will generally depend on the source and composition of any naphtha or r-naphtha streams combined with the light r-pyoil stream or otherwise included in the reformer feedstock. For example, when the feedstock comprises high olefin and/or sulfur content (e.g., greater than 10 ppm, greater than 100 ppm, greater than 500 ppm, or greater than 1,000 ppm sulfur), then hydrotreating is generally needed before introducing the feedstock to the reformer.

[00073] In one or more embodiments or in combination with any embodiment mentioned herein, at least a portion of the feedstock (e.g., naphtha, r-naphtha, and/or light r-pyoil) that undergoes reforming comprises less than 500 ppm, less than 450 ppm, less than 350 ppm, less than 250 ppm, less than 100 ppm, less than 75 ppm, less than 50 ppm, less than 25 ppm, or less than 10 ppm sulfur. In one or more embodiments, at least a portion of the feedstock (e.g., naphtha, r-naphtha, and/or light r-pyoil) that undergoes reforming comprises less than 300 ppm, less than 150 ppm, less than 100 ppm, less than 50 ppm, less than 25 ppm, less than 10 ppm, or less than 5 ppm chlorine. In one or more embodiments, at least a portion of the feedstock (e.g., naphtha, r-naphtha, and/or light r-pyoil) that undergoes reforming comprises less than 500 ppm, less than 250 ppm, less than 100 ppm, less than 75 ppm, less than 50 ppm, less than 30 ppm, or less than 20 ppm water. In one or more embodiments, at least a portion of the feedstock (e.g., naphtha, r-naphtha,

and/or light r-pyoil) that undergoes reforming comprises less than 500 ppb, less than 250 ppb, less than 100 ppb, less than 50 ppb, less than 25 ppb, less than 10 ppb, less than 5 ppb, or less than 2 ppb arsenic. In one or more embodiments, at least a portion of the feedstock (e.g., naphtha, r-naphtha, and/or light r-pyoil) that undergoes reforming comprises less than 1500 ppm, less than 1000 ppm, less than 500ppm, less than 250 ppm, less than 100 ppm, less than 75 ppm, less than 50 ppm, less than 30 ppm, or less than 20 ppm nitrogen.

[00074] As depicted FIG. 4, along with the recycled content pyrolysis oil (r-pyoil) and the naptha and/or r-naphtha from the refinery processes (e.g., ADU), naphtha contained in a natural gasoline from a natural gas liquids (NGL) processing plant may also be introduced as a reformer feedstock. Thus, in one embodiment or in combination with any embodiments mentioned herein, at least a portion of the naphtha stream making up at least a portion of the reformer feedstock may comprise one or more of: (i) a naphtha product stream from an atmospheric distillation unit (ADU); (ii) a hydrocracked gasoline stream; (iii) a fluidized catalytic cracker (FCC) gasoline stream; (iv) a raffinate from an aromatics complex; and/or (v) a natural gasoline from a natural gas liquids (NGL) processing plant. The individual naphtha, r-naphtha, and/or light r-pyoil streams may optionally undergo hydrotreating and/or nitrogen removal processes, as described herein, and/or one or more of these streams may be combined and undergo hydrotreating and/or nitrogen removal processes as a single process stream. Regardless, the resulting feedstock can then be catalytically reformed in the reformer to produce a recycled content reformate (r-reformate). The r-reformate may then be introduced to the aromatics complex, along with any other aromatics-containing feedstock streams, and processed to produce recycled content para-xylene (r-pX), as described herein.

[00075] In one or more embodiments or in combination with any embodiment mentioned herein, the r-naptha from the ADU and/or the light

r-pyoil can be fed to the catalytic reformer, along with one or more other naphtha and/or r-naphtha containing streams, as feedstock, to produce a reformate stream comprising recycled content reformate (r-reformate). In greater detail, the feedstock is reacted in the presence of a catalyst and hydrogen to form a reformate stream comprising C6 to C10 aromatics and other unsaturated compounds of a similar carbon number. More specifically, the reformer unit reacts generally saturated alkanes (e.g., linear, branched, and cyclic hydrocarbons) in the naphtha (or r-naphtha) feedstock to form higher-octane unsaturated hydrocarbons, such as, for example, benzene, toluene, xylenes, styrene, etc., via dehydrogenation and/or chemical rearrangement. The reformer unit also produces a byproduct stream of hydrogen (or recycled content hydrogen, r-H2), which can be used in other hydroprocessing units within or external to the refinery.

[00076] When at least a portion of the reformer feedstock comprises recycled content (e.g., r-pyoil, r-naphtha and/or a yet-to-be-discussed r-raffinate stream as shown in FIG. 3), the reformate stream can be a recycled content reformate (r-reformate) stream. The feed to the reformer may include at least one feed stream (e.g., naphtha) that does not include recycled content derived from waste plastic. As a result, the r-reformate may also include non-recycled content hydrocarbon. It should be understood that one or more of the components of the reformate described herein may or may not include recycled content derived from waste plastic, depending on the feedstock processed in the reformer.

[00077] In one embodiment or in combination with any embodiment mentioned herein, the reformate (or r-reformate) withdrawn from the reformer comprises predominantly C6 to C10 (or C6 to C9) aromatics, or it can include at least 55, at least 60, at least 65, at least 70, at least 75, at least 80, at least 85, or at least 90 weight percent of C6 to C10 (or C6 to C9) aromatic components. It may also include less than 45, less than 35,

less than 25, less than 15, or less than 10 weight percent of non-aromatic components.

[00078] The reformate (or r-reformate) may also include at least 1, at least 2, at least 3, at least 5, or at least 10 and/or not more than 30, not more than 25, not more than 20, not more than 15, not more than 10, or not more than 7 weight percent of benzene, which may include recycled content benzene (r-benzene) and/or non-recycled content benzene. Additionally, or in the alternative, the reformate (or r-reformate) may also include at least 5, at least 10, at least 15, or at least 20 and/or not more than 40, not more than 35, not more than 30, not more than 25, or not more than 20 weight percent of toluene, which can include both recycled content toluene (r-toluene) and/or non-recycled content toluene.

[00079] The reformate (or r-reformate) may also include at least 5, at least 10, at least 15, at least 20, or at least 25 weight percent and/or not more than 75, not more than 70, not more than 65, not more than 60, not more than 55, not more than 50, not more than 45, not more than 40, not more than 35, not more than 30, or not more than 25 weight percent of one or more of C8 aromatics (or recycled content C8 aromatics, r-C8 aromatics), C9 aromatics (or recycled content C9 aromatics, r-C9 aromatics), and C10 aromatics (or recycled content C10 aromatics, r-C10 aromatics, individually or in combination. Examples of C8 aromatics include, but are not limited to, mixed xylenes such as ortho-xylene, para-xylene, and meta-xylene, as well as ethylbenzene, and styrene, while C9 aromatics can include, for example, isopropyl benzene, propyl benzene, isomers of methyl ethyl benzene, and isomers of trimethyl benzene. Examples of C10 aromatics can include, but are not limited to, isomers of butyl benzene, isomers of diethyl benzene, and isomers of dimethyl ethyl benzene. One or more of these components, when present in the reformate stream, may include recycled content and/or may include non-recycled content. The r-reformate may include, for example, at least 5, at least 10, or at least 15 and/or not more than 50, not more than 45, or not

more than 40 weight percent of mixed xylenes, including recycled and non-recycled content xylenes.

[00080] The reformate (or r-reformate) stream may comprise very little, if any, C5 and lighter components and/or C11 and heavier components. For example, the reformate (or r-reformate) can include not more than 15, not more than 10, not more than 5, not more than 2, or not more than 1 weight percent of C5 and lighter components and/or C11 and heavier components. The total amount of C6 to C10 (or C9 to C10) hydrocarbon components in the reformate (or r-reformate) stream can be at least 55, at least 60, at least 65, at least 70, at least 75, at least 80, at least 85, or at least 90 weight percent, based on the total weight of the stream.

[00081] At least a portion of the reformate stream comprising r-reformate can then be fed to the aromatics complex.

[00082] In addition to the r-reformate, other sources of recycled content aromatics (including recycled content para-xylene (r-px)) may be produced in the refinery and introduced to the aromatics complex. For example, recycled content pyrolysis oil (r-pyoil) and a crude oil feed may be processed within at least one distillation column within the refinery, and in particular, one or more distillation columns of an ADU and/or VDU. Within these distillation units, recycled content AGO, LVGO, and/or HVGO can be produced along with a recycled content heavy naphtha cut and other lighter hydrocarbon cuts. In one or more embodiments, the recycled content heavy hydrocarbon streams can be individually fed, or combined and fed, to a cracking facility, such as a steam cracking facility, in which the average molecular weight of the heavy hydrocarbon streams are reduced. The cracking facility generally includes a cracker furnace for thermally cracking the hydrocarbon-containing feed, a quench zone for cooling the cracked effluent, a compression zone for increasing the pressure of the cooled, cracked stream, and a separation zone for separating out one or more recycled content hydrocarbon product (r-hydrocarbon product) streams from the compressed effluent. Examples of

r-product streams can include, but are not limited to, recycled content ethylene (r-ethylene), recycled content ethane (r-ethane), recycled content propylene (r-propylene), recycled content propane (r-propane), recycled content butylene (r-butylene), recycled content butane (r-butane), and recycled content C5 and heavier (r-C5+). As shown, the cracking facility can produce a recycled content pyrolysis gasoline stream. At least a portion of the r-pyrolysis gasoline stream may then be fed to the aromatics complex.

[00083] In one embodiment or in combination with any embodiments mentioned herein, the r-pyrolysis gasoline stream comprises at least 20, at least 25, at least 30, at least 35, at least 40, at least 45, or at least 50 weight percent and/or not more than 85, not more than 80, not more than 75, not more than 70, not more than 65, or not more than 60 weight percent of recycled content benzene, recycled content toluene, and recycled content xylenes (r-BTX). In one embodiment or in combination with any embodiments mentioned herein, the r-pyrolysis gasoline can also include at least 5, at least 10, or at least 15 weight percent and/or not more than 45, not more than 35, not more than 30, or not more than 25 weight percent of recycled content C9 to C12 aromatics and/or recycled content C6 and heavier cyclic hydrocarbons (r-C6+ cyclic hydrocarbons).

[00084] In one embodiment or in combination with any embodiments mentioned herein, the r-BTX in the r-pyrolysis gasoline can include at least 25, at least 30, at least 35, at least 40, or at least 45 weight percent and/or not more than 75, not more than 70, not more than 65, not more than 60, not more than 55, or not more than 50 weight percent of benzene, and/or at least 15, at least 20, at least 25, or at least 30 weight percent and/or not more than 65, not more than 60, not more than 55, not more than 50, not more than 45, not more than 40, or not more than 35 weight percent of toluene. Additionally, or in the alternative, the r-BTX in the r-pyrolysis gasoline can include at least 5, at least 10, at least 15, or at least 20 weight percent and/or not more than 50, not more than 45, not more than

35, not more than 30, or not more than 25 weight percent of mixed xylenes, including ortho-xylene (oX), meta-xylene (mX), and para-xylene (pX). At least a portion of the benzene, toluene, and/or xylenes in the r-BTX can comprise recycled content benzene, recycled content toluene, and/or recycled content xylenes, while, in other cases, at least a portion of the benzene, toluene, and/or xylenes may include non-recycled content.

[00085] Turning again to FIG. 1, at least a portion of the r-reformate produced from the reformer can be introduced into an aromatics complex along with any other naphtha and/or naphtha containing streams, such as r-pyrolysis gasoline, wherein the aromatics-containing stream(s) can be processed to provide a recycled content paraxylene (r-paraxylene) stream. The r-paraxylene stream, which comprises recycled content paraxylene (r-pX), can also include non-recycled content components, including non-recycled content paraxylene (pX). The r-paraxylene stream can include at least 55, at least 60, at least 65, at least 70, at least 75, at least 80, at least 85, at least 90, at least 95, at least 97, or at least 99 percent of r-pX, based on the total amount of r-pX and pX in the stream. The total amount of paraxylene in the r-paraxylene stream (including both pX and r-pX) can be at least 85, at least 90, at least 92, at least 95, at least 97, at least 99, or at least 99.5 weight percent. In some cases, all of the paraxylene in the r-paraxylene stream can be r-pX.

[00086] As depicted in FIGS. 1, 3, and 5, and described in further detail below, the aromatics complex may produce an r-raffinate stream from a separation section, and in particular, from an extraction unit. The r-raffinate stream may be depleted in aromatics and comprises predominantly C5 to C12 components and may include not more than 20, not more than 15, not more than 10, or not more than 5 weight percent of C6 to C9 aromatics (e.g., benzene, toluene, and xylenes). The r-raffinate stream may be combined with at least a portion of a heavy r-naphtha stream produced from the ADU, light pyoil, and/or other reformer feedstock stream. For example, the r-raffinate stream may be combined

with the heavy r-naphtha stream and/or light pyoil stream and the combined stream optionally hydrotreated and/or subjected to nitrogen removal before being fed to the reformer.

[00087] Referring now to FIG. 5, a schematic diagram of the main steps/zones of an aromatics complex as shown in FIG. 1 is provided. In one embodiment or in combination with any embodiments mentioned herein, an aromatics-containing feed (r-aromatics feed) may also be introduced into the initial separation step. This feed may comprise one or more aromatics-containing streams. For example, the r-aromatics feed may comprise an r-reformate steam produced from the reformer and/or r-pyrolysis gasoline from the steam cracking facility, as described herein. The other aromatics-containing feed stream may include recycled content and/or non-recycled content and can optionally originate from one or more other facilities.

[00088] In one embodiment or in combination with any embodiments mentioned herein, the initial separation zone may remove at least 50, at least 60, at least 75, at least 80, or at least 90 weight percent of the total amount of aromatics introduced into the separation zone, resulting in an aromatics-enriched predominantly benzene, toluene, and xylene (BTX) stream and an aromatics-depleted raffinate stream. The BTX stream may comprise at least at least 55, at least 65, at least 75, at least 85, or at least 90 weight percent C6 to C9 aromatics, while the raffinate stream can comprise less than 50, less than 40, less than 30, less than 20, or less than 10 weight percent C6 to C9 aromatics. When one or more of the feed streams to the initial separation zone comprise recycled content, the BTX stream can be a recycled content BTX (r-BTX) stream, and the raffinate stream may be a recycled content raffinate (r-raffinate) stream.

[00089] In addition to BTX, the r-BTX stream may include other aromatic and non-aromatic components. For example, the r-BTX (or BTX) stream may include at least 1, at least 2, at least 5, or at least 10 weight percent and/or not more than 25, not more than 20, not more than 15, or not more

than 10 weight percent of C9 and heavier (or C10 and heavier) components. Such components can include C9 and heavier (or C10 and heavier) aromatic components as well as non-aromatic C9 and heavier (or C10 and heavier) components.

[00090] The initial separation step shown in FIG. 5 for removing BTX from the incoming stream(s) may be performed using any suitable type of separation, including extraction, distillation, and extractive distillation. When the separation step includes extraction or extractive distillation, it may utilize at least one solvent selected from the group consisting of sulfolane, furfural, tetraethylene glycol, dimethylsulfoxide, N,N-dimethylformamide, and N-methyl-2-pyrrolidone. Upon separation, a recycled content raffinate (r-raffinate) stream depleted in aromatics can be withdrawn from the separation step/zone. The r-raffinate stream comprises predominantly C5 to C12 components and may include not more than 20, not more than 15, not more than 10, or not more than 5 weight percent of C6 to C9 aromatics (e.g., benzene, toluene, and xylenes).

[00091] Additionally, as shown in FIG. 5, a stream concentrated in recycled content benzene, toluene, and xylenes (r-BTX) can also be withdrawn from the initial separation step. This r-BTX stream comprises predominantly BTX and may include at least 60, at least 70, at least 80, at least 85, at least 90, or at least 95 BTX, including both recycled content BTX (r-BTX) and non-recycled content BTX, as applicable. This stream may also include at least 5, at least 10, at least 15 and/or not more than 30, not more than 25, not more than 20, and/or not more than 10 weight percent of lighter and/or heavier components, such as styrene. The r-BTX stream can be introduced into a downstream BTX recovery zone, which utilizes one or more separation steps to provide streams concentrated in recycled content benzene (r-benzene), recycled content mixed xylenes (r-mixed xylenes), and recycled content toluene (r-toluene). Such separations can be performed according to any suitable method, including,

for example, with one or more distillation columns or other separation equipment or steps.

[00092] As discussed previously, this r-BTX stream may include other C8 aromatics (such as ethylbenzene), as well as C9 and heavier (or C10 and heavier) components in addition to the benzene, toluene, and mixed xylenes. Components other than BTX in the r-BTX stream may be present in an amount of at least 1, at least 2, at least 5, or at least 10 weight percent and/or not more than 25, not more than 20, not more than 15, or not more than 10 weight percent.

[00093] As shown in FIG. 5, the r-benzene formed in BTX recovery step can be removed as a product stream from aromatics complex, while the r-mixed xylenes can be introduced into a second separation step for separating out recycled content ortho-xylene (r-oX), recycled content meta-xylene (r-mX), and/or recycled content paraxylene (r-pX) from the other components in the stream. In addition to comprising at least 25, at least 30, at least 35, at least 40, or at least 45 weight percent and/or not more than 70, not more than 65, not more than 60, or not more than 55 weight percent mixed xylenes, this stream of r-mixed xylenes may also include other C8 aromatics (such as ethylbenzene), as well as C9 and heavier (or C10 and heavier) aromatic and non-aromatic components. Such components (which may include recycled content or non-recycled content components) can be present in the r-BTX stream in an amount of at least 1, at least 2, at least 5, or at least 10 weight percent and/or not more than 35, not more than 30, not more than 25, not more than 20, not more than 15, not more than 10, or not more than 5 weight percent.

[00094] This second separation step can utilize one or more of distillation, extraction, crystallization, and adsorption to provide recycle content aromatics streams. For example, as shown in FIG. 5, the separation step can provide at least one of a recycled content paraxylene (r-paraxylene) stream, a recycled content metaxylene (r-metaxylene) stream, and a recycled content orthoxylene (r-orthoxylene) stream. Each of these

streams may include both recycled and non-recycled content and can individually include at least 75, at least 80, at least 85, at least 90, at least 95, or at least 97 weight percent of paraxylene (r-pX and pX), metaxylene (r-mX and mX), or orthoxylene (r-oX and oX), respectively.

[00095] Additionally, at least a portion of the oX (or r-oX) and/or mX (or r-mX) can be subjected to isomerization to provide additional pX (or r-pX). After the isomerization, additional separation steps may be performed to provide individual streams of oX (or r-oX), mX (or r-mX), and pX (or r-pX).

[00096] As shown in FIG. 5, a stream of recycled content C9 and heavier components (r-C9+ components) may also be withdrawn from the second separation step and all or a portion may be introduced into a transalkylation/disproportionation step along with a stream of r-toluene withdrawn from the BTX recovery step/zone. In the transalkylation/disproportionation step/zone, at least a portion of the toluene (or r-toluene) can be reacted in the presence of a regenerable fixed bed silica-alumina catalyst to provide mixed xylenes (or r-mixed xylenes) and benzene (or r-benzene). Alternatively, or in addition, at least a portion of the r-toluene can be reacted with methanol (and, optionally, r-methanol) to provide recycled content paraxylene (r-paraxylene), which may be further processed as described herein. In some cases, this reaction may be performed within the aromatics complex over an acidic catalyst, preferably on a shape-selective molecular sieve catalyst such as ZSM-5, and the resulting r-paraxylene may be combined with other paraxylene (or r-paraxylene) recovered in the aromatics complex, as shown in FIG. 5. As shown in FIG. 5, the benzene (or r-benzene) can be recovered as a product, while the r-mixed xylenes can be introduced into the second separation step/zone for further separation into a r-paraxylene stream, an r-orthoxylene stream, and a r-metaxylene stream.

[00097] Turning back to FIG. 1, at least a portion of the r-paraxylene stream withdrawn from the aromatics complex can be sent to a TPA production facility. In the TPA production facility, at least a portion of the pX (and/or r-

pX) in the r-paraxylene stream can be oxidized in the presence of a solvent (e.g., acetic acid) and a catalyst to form recycled content crude terephthalic acid (r-CTA).

[00098] Thereafter, depending on the specific TPA production process utilized within the production facility, the r-CTA can either be oxidized again in a secondary or post-oxidation step or it can be hydrogenated in a treatment step to form recycled content purified terephthalic acid (r-PTA). All or a portion of the solvent may be removed from the r-CTA and swapped out for new solvent, which may be the same as or different than the original solvent. The resulting r-PTA slurry can be processed by, for example, drying, crystallization, and filtration to provide the final r-TPA product.

[00099] In one embodiment or in combination with any embodiments mentioned herein, as shown in FIG. 1, at least a portion of the r-TPA product can be introduced into a PET production facility and reacted with at least one diol (such as, for example, ethylene glycol) to form recycled content polyethylene terephthalate (r-PET). In one embodiment or in combination with any embodiments mentioned herein, the r-TPA and ethylene glycol (or, recycled content ethylene glycol, r-EG, and/or sustainable or bio-based ethylene glycol, s-EG) can be polymerized in the presence of one or more comonomers, such as isophthalic acid or neopentyl glycol or cyclohexanedimethanol, to form a recycled content PET copolymer (r-co-PET).

DEFINITIONS

[000100] It should be understood that the following is not intended to be an exclusive list of defined terms. Other definitions may be provided in the foregoing description, such as, for example, when accompanying the use of a defined term in context.

[000101] As used here, the term “light gas” refers to a hydrocarbon-containing stream comprising at least 50 weight percent of C4 and lighter

hydrocarbon components. Light hydrocarbon gas may include other components such as nitrogen, carbon dioxide, carbon monoxide, and hydrogen, but these are typically present in amount of less than 20, less than 15, less than 10, or less than 5 weight percent, based on the total weight of the stream.

[000102] As used herein, the terms "median boiling point" or "T50" refers to the median boiling point of a process stream (i.e., the temperature value where 50 weight percent of the stream composition boils above the temperature value and 50 weight percent of the stream composition boils below the temperature value).

[000103] As used herein, the term "boiling point range" or "cut point" refers to the range of temperatures over which a specified petroleum fraction boils. The lower value in a boiling point range is the initial boiling point (IBP) temperature for that specified fraction and the higher value is the end point (EP) temperature for that specified fraction.

[000104] As used herein, the term "naphtha" refers to a physical mixture of hydrocarbon components separated in at least one distillation column of a refining facility that has a boiling point range between 90 to 380°F.

[000105] As used herein, the term "light naphtha" refers to a specific portion of a naphtha cut in a refinery having a boiling point range between 90 and 190°F.

[000106] As used herein, the term "heavy naphtha" refers to a specific portion of a naphtha cut in a refinery having a boiling point range between 190 and 380°F.

[000107] As used herein, the terms "distillate" and "kerosine" refer to a physical mixture of hydrocarbon components separated in at least one distillation column of a refining facility that has a boiling point range greater than 380 to 520°F.

[000108] As used herein, the term "hydrocracker distillate" refers to a distillate cut removed from a hydrocracker unit.

[000109] As used herein, the term "gas oil" refers to a physical mixture of hydrocarbon components separated in at least one distillation column of a refining facility that has a boiling point range greater than 520 to 1050°F.

[000110] As used herein, the term "atmospheric gas oil" refers to a gas oil produced by the atmospheric distillation unit.

[000111] As used herein, the term "light gas oil" or "LGO" refers to a specific portion of gas oil cut in a refinery having a boiling point range between greater than 520 and 610°F.

[000112] As used herein, "light vacuum gas oil" or "LVGO" refers to a light gas oil produced by the vacuum distillation unit.

[000113] As used herein, "light vacuum gas oil" or "LCGO" refers to a light gas oil produced by the coker unit.

[000114] As used herein, the term "heavy gas oil" or "HGO" refers to a specific portion of a gas oil cut in a refinery having a boiling point range between greater than 610 and 800°F.

[000115] As used herein, "heavy vacuum gas oil" or "HVGO" refers to a heavy gas oil produced by the vacuum distillation unit.

[000116] As used herein, "heavy coker gas oil" or "HCGO" refers to a heavy gas oil produced by the coker unit.

[000117] As used herein, the term "vacuum gas oil" or "VGO" refers to a specific portion of a gas oil cut in a refinery having a boiling point range between greater than 800 and 1050°F. Vacuum gas oil is separated from the initial crude oil using a vacuum distillation column operated at a pressure below atmospheric pressure.

[000118] As used herein, the term "residue" or "resid" refers to the heaviest cut from a distillation column in a refinery and having a boiling point range between greater than 1050°F.

[000119] As used herein, the term "vacuum resid" refers to a resid product from the vacuum distillation column.

[000120] As used herein, the term "atmospheric resid" refers to a resid product from the atmospheric distillation column.

[000121] As used herein, the term "gas plant" refers to equipment, including one or more distillation columns as well as ancillary equipment as well as pumps, compressors, valves, etc. in a refinery for processing a hydrocarbon feed stream comprising predominantly C6 and lighter components to provide one or more purified streams of C1 to C6 alkanes and/or olefins.

[000122] As used herein, the term "saturated gas plant" refers to a gas plant in a refinery for processing a hydrocarbon feed stream comprising predominantly saturated hydrocarbons (alkanes). The feed stream to a saturated gas plant includes less than 5 weight percent of olefins, based on the total feed to the plant. The feed to a saturated gas plant in a refinery may come, directly or indirectly, from the crude distillation unit or vacuum distillation unit and may undergo little or no cracking.

[000123] As used herein, the term "unsaturated gas plant" refers to a gas plant in a refinery for processing a hydrocarbon feed stream comprising saturated hydrocarbons (alkanes) and unsaturated hydrocarbons (olefins). The feed stream to an unsaturated gas plant includes at least 5 weight percent of olefins, based on the total feed to the plant. The feed to a saturated gas plant in a refinery may come indirectly from the crude unit or vacuum distillation unit and may undergo one or more cracking steps prior to entering the gas plant.

[000124] As used herein, the term "gas oil cracker" refers to a cracking unit for processing a feed stream comprising predominantly gas oil and heavier components. Although a gas oil cracker can process lighter components, such as distillate and naphtha, at least 50 weight percent of the total feed to a gas oil cracker includes gas oil and heavier components. Gas oil crackers may be operated at temperatures of at least 350°F, at least 400°F, at least 450°F, at least 500°F, at least 550°F, or at least 600°F and/or not more than 1200°F, not more than 1150°C, not more than 1100°F, not more than 1050°F, not more than 1000°F, not more than 900°F, or not more than 800°F. Gas oil crackers may be operated at or

near atmospheric pressure (e.g., at a pressure of less than 5 psig, less than 2 psig, or 1 psig) or may be operated at elevated pressure (e.g., at a pressure of at least 5 psig, at least 10 psig, at least 25 psig, at least 50 psig, at least 100 psig, at least 250 psig, at least 500 psig, or at least 750 psig.) Additionally, the cracking in gas oil crackers may be carried with or without a catalyst, and it may or may not be conducted in the presence of hydrogen and/or steam.

[000125] As used herein, the term "fluidized catalytic cracker" or "FCC" refers to a set of equipment, including a reactor, a regenerator, a main fractionator, as well as ancillary equipment such as pipes, valves, compressors, and pumps, for reducing the molecular weight of a heavy hydrocarbon stream via catalytic cracking in a fluidized catalyst bed.

[000126] As used herein, the terms "reformer" or "catalytic reformer" refer to a process or facility in which a feedstock comprising predominantly C6-C10 alkanes is converted to a reformate comprising branched hydrocarbons and/or cyclic hydrocarbons in the presence of a catalyst.

[000127] As used herein, the term "reformate" refers to a liquid product stream produced by a catalytic reformer process.

[000128] As used herein, the term "hydroprocessing" refers to chemical processing of a hydrocarbon stream with or in the presence of hydrogen. Hydroprocessing is typically a catalytic process and includes hydrocracking and hydrotreating.

[000129] As used herein, the term "hydrocracking" refers a type of hydroprocessing where the hydrocarbon molecules are cracked (i.e., undergo a reduction in molecular weight).

[000130] As used herein, the term "hydrotreating" refers to a type of hydroprocessing that does not crack the hydrocarbon molecules, but instead removes oxygen, sulfur, and other heteroatoms by hydrogenolysis or to saturate unsaturated bonds by hydrogenation. It may or may not be carried out in the presence of a catalyst.

[000131] As used herein, the term “distillation” refers to separation of a mixture of components by boiling point difference.

[000132] As used herein, the term “atmospheric distillation” refers to distillation performed at a pressure at or near atmospheric, usually to separate crude oil and/or other streams into specified fractions for further processing.

[000133] As used herein, the term “vacuum distillation” refers to distillation performed at a pressure below atmospheric and, usually, at a pressure of less than 100 mm Hg at the top of the column.

[000134] As used herein, the term “coking” refers to thermal cracking of heavy hydrocarbons (usually atmospheric or vacuum column bottoms) performed to recover light, more valuable products such as naphtha, distillate, gas oil, and light gas.

[000135] As used herein, the term “aromatics complex” refers to a process or facility in which a mixed hydrocarbon feedstock, such as a reformate, is converted into one or more benzene, toluene, and/or xylene (BTX) product streams, such as a para-xylene product stream. The aromatics complex may comprise one or more processing steps, in which one or more components of the reformate are subjected to at least one of a separation step, an alkylation step, a transalkylation step, a toluene disproportionation step, and/or an isomerization step. The separation step can comprise one or more of an extraction step, a distillation step, a crystallization step, and/or an adsorption step.

[000136] As used herein, the term “raffinate” refers to the aromatics-depleted stream removed from the initial separation step in the aromatics complex. Although most commonly used to refer to a stream withdrawn from an extraction step, the term “raffinate” as used with respect to the aromatics complex can also refer to a stream withdrawn from another type of separation, including, but not limited to, distillation or extractive distillation.

[000137] As used herein, the terms “pyrolysis oil” or “pyoil” refers to a composition obtained from pyrolysis that is liquid at 25°C and 1 atm, absolute.

[000138] As used herein, the terms “pyrolysis gas” and “pygas” refer to a composition obtained from pyrolysis that is gaseous at 25°C and 1 atm, absolute.

[000139] As used herein, the term “pyrolysis” refers to thermal decomposition of one or more organic materials at elevated temperatures in an inert (i.e., substantially oxygen free) atmosphere.

[000140] As used herein, the term “pyrolysis vapor” refers to the overhead or vapor-phase stream withdrawn from the separator in a pyrolysis facility used to remove r-pyrolysis residue from the r-pyrolysis effluent.

[000141] As used herein, the term “pyrolysis effluent” refers to the outlet stream withdrawn from the pyrolysis reactor in a pyrolysis facility.

[000142] As used herein, the term “r-pyrolysis residue” refers to a composition obtained from waste plastic pyrolysis that comprises predominantly pyrolysis char and pyrolysis heavy waxes.

[000143] As used herein, the term “pyrolysis char” refers to a carbon-containing composition obtained from pyrolysis that is solid at 200°C and 1 atm, absolute.

[000144] As used herein, the term “pyrolysis heavy waxes” refers to C20+ hydrocarbons obtained from pyrolysis that are not pyrolysis char, pyrolysis gas, or pyrolysis oil.

[000145] As used herein, the term “pyrolysis gasoline” refers to a hydrocarbon stream of predominantly C5 and heavier components removed from a quench section of a steam cracking facility. Typically, pyrolysis gasoline includes at least 10 weight percent of C6 to C9 aromatics.

[000146] As used herein, the term “lighter” refers to a hydrocarbon component or fraction having a lower boiling point than another hydrocarbon component or fraction.

[000147] As used herein, the term "heavier" refers to a hydrocarbon component or fraction having a higher boiling point than another hydrocarbon component or fraction.

[000148] As used herein, the term "upstream" refers to an item of facility that is positioned prior to another item or facility in a given process flow and may include intervening items and/or facilities.

[000149] As used herein, the term "downstream" refers to an item or facility that is positioned after another item or facility in a given process flow and may include intervening items and/or facilities.

[000150] As used herein, the term "alkane" refers to a saturated hydrocarbon including no carbon-carbon double bonds.

[000151] As used herein, the term "olefin" refers to an at least partially unsaturated hydrocarbon including at least one carbon-carbon double bond.

[000152] As used herein, the terms "Cx" or "Cx hydrocarbon" or "Cx component" refers to a hydrocarbon compound including "x" total carbons per molecule, and encompasses all olefins, paraffins, aromatics, heterocyclic, and isomers having that number of carbon atoms. For example, each of normal, iso, and tert-butane and butene and butadiene molecules would fall under the general description "C4" or "C4 components."

[000153] As used herein, the terms "r-para-xylene" or "r-pX" refer to being or comprising a para-xylene product that is directly and/or indirectly derived from waste plastic.

[000154] As used herein, the term "cracking" refers to breaking down complex organic molecules into simpler molecules by the breaking of carbon-carbon bonds.

[000155] As used herein, the term "steam cracking" refers to thermal cracking of hydrocarbons in the presence of steam, usually performed in a furnace of the steam cracking facility.

[000156] As used herein, the term "co-located" refers to the characteristic of at least two objects being situated on a common physical site, and/or within five miles of each other, measured as a straight-line distance between two designated points.

[000157] As used herein, the term "commercial scale facility" refers to a facility having an average annual feed rate of at least 500 pounds per hour, averaged over one year.

[000158] As used herein, the terms "crude" and "crude oil" refer to a mixture of hydrocarbons that exists in liquid phase and is derived from natural underground reservoirs.

[000159] As used herein, the terms "recycle content" and "r-content" refer to being or comprising a composition that is directly and/or indirectly derived from waste plastic.

[000160] As used herein, the term "predominantly" means more than 50 percent by weight. For example, a predominantly propane stream, composition, feedstock, or product is a stream, composition, feedstock, or product that contains more than 50 weight percent propane.

[000161] As used herein, the term "waste material" refers to used, scrap, and/or discarded material.

[000162] As used herein, the terms "waste plastic" and "plastic waste" refer to used, scrap, and/or discarded plastic materials, including post-industrial or pre-consumer waste plastic and post-consumer waste plastic.

[000163] As used herein, the terms "mixed plastic waste" and "MPW" refer to a mixture of at least two types of waste plastics including, but not limited to the following plastic types: polyethylene terephthalate (PET), one or more polyolefins (PO), and polyvinylchloride (PVC).

[000164] As used herein, the term "fluid communication" refers to the direct or indirect fluid connection between two or more processing, storage, or transportation facilities or zones.

[000165] As used herein, the terms "a," "an," and "the" mean one or more.

[000166] As used herein, the term "and/or," when used in a list of two or more items, means that any one of the listed items can be employed by itself or any combination of two or more of the listed items can be employed. For example, if a composition is described as containing components A, B, and/or C, the composition can contain A alone; B alone; C alone; A and B in combination; A and C in combination, B and C in combination; or A, B, and C in combination.

[000167] As used herein, the phrase "at least a portion" includes at least a portion and up to and including the entire amount or time period.

[000168] As used herein, the term "chemical recycling" refers to a waste plastic recycling process that includes a step of chemically converting waste plastic polymers into lower molecular weight polymers, oligomers, monomers, and/or non-polymeric molecules (e.g., hydrogen, carbon monoxide, methane, ethane, propane, ethylene, and propylene) that are useful by themselves and/or are useful as feedstocks to another chemical production process(es).

[000169] As used herein, the terms "comprising," "comprises," and "comprise" are open-ended transition terms used to transition from a subject recited before the term to one or more elements recited after the term, where the element or elements listed after the transition term are not necessarily the only elements that make up the subject.

[000170] As used herein, the terms "including," "include," and "included" have the same open-ended meaning as "comprising," "comprises," and "comprise" provided above.

[000171] As used herein, the term "predominantly" means more than 50 percent by weight. For example, a predominantly propane stream, composition, feedstock, or product is a stream, composition, feedstock, or product that contains more than 50 weight percent propane.

[000172] As used herein, the term "chemical pathway" refers to the chemical processing step or steps (e.g., chemical reactions, physical separations, etc.)

between an input material and a product, where the input material is used to make the product.

[000173] As used herein, the term "mass balance" refers to a method of tracing recycled content based on the mass of the recycled content in a product.

[000174] As used herein, the terms "physical recycled content" and "direct recycled content" both refer to matter physically present in a product and that is physically traceable back to a waste material.

[000175] As used herein, the term "recycled content" refers to being or comprising a composition that is directly and/or indirectly derived from recycled waste material. Recycled content is used generically to refer to both physical recycled content and credit-based recycled content. Recycled content is also used as an adjective to describe a product having physical recycled content and/or credit-based recycled content.

[000176] As used herein, the term "recycled content credit" refers to a non-physical measure of physical recycled content obtained from a mass of waste plastic that can be directly or indirectly (i.e., via a digital inventory) attributed to a product.

[000177] As used herein, the term "hydroprocessing unit" refers to a set of equipment, including reaction vessels, a drier, and a main fractionator, as well as ancillary equipment such as pipes, valves, compressors, and pumps, for chemically processing a hydrocarbon stream in the presence of hydrogen. Specific examples of hydroprocessing units include a hydrocracker (or hydrocracking unit) configured to carry out a hydrocracking process and a hydrotreater (or hydrotreating unit) configured to carry out a hydrotreating process.

[000178] As used herein, the term "coker" or "coking unit" refers to a set of equipment, including reaction vessels, a drier, and a main fractionator, as well as ancillary equipment such as pipes, valves, compressors, and pumps, for reducing the molecular weight of a heavy hydrocarbon stream via thermal cracking or coking.

[000179] As used herein, the terms "steam cracking facility" or "steam cracker" refer to all of the equipment needed to carry out the processing steps for thermally cracking a hydrocarbon feed stream in the presence of

steam to form one or more cracked hydrocarbon products. Examples include, but are not limited to, olefins such as ethylene and propylene. The facility may include, for example, a steam cracking furnace, cooling equipment, compression equipment, separation equipment, as well as the pipes, valves, tanks, pumps, etc. needed to carry out the processing steps.

[000180] As used herein, the terms "refinery," "refining facility," and "petroleum refinery," refer to all of the equipment needed to carry out the processing steps for separating and converting petroleum crude oil into multiple hydrocarbon fractions, one or more of which can be used as a fuel source, lube oil, bitumen, coke, and as an intermediate for other chemical products." The facility may include, for example, separation equipment, thermal or catalytic cracking equipment, chemical reactors, and product blending equipment, as well as the pipes, valves, tanks, pumps, etc. needed to carry out the processing steps.

[000181] As used herein, the term "pyrolysis facility," refers to all of the equipment needed to carry out the processing steps for pyrolyzing a hydrocarbon-containing feed stream, which can include or be waste plastic. The facility may include, for example, reactors, cooling equipment, and separation equipment, as well as the pipes, valves, tanks, pumps, etc. needed to carry out the processing steps.

[000182] As used herein, the term "terephthalic acid production facility," or "TPA production facility," refers to all of the equipment needed to carry out the processing steps for forming terephthalic acid from paraxylene. The facility may include, for example, reactors, separators, cooling equipment, separation equipment such as filters or crystallizers, as well as the pipes, valves, tanks, pumps, etc. needed to carry out the processing steps.

[000183] As used herein, the term "polyethylene terephthalate production facility," or "PET production facility," refers to all of the equipment needed to carry out the processing steps for forming polyethylene terephthalate (PET) from a terephthalate, ethylene glycol, and, optionally, one or more additional monomers. The facility may include, for example,

polymerization reactors, cooling equipment, and equipment to recover solidified and/or pelletized PET, as well as the pipes, valves, tanks, pumps, etc. needed to carry out the processing steps.

CLAIMS NOT LIMITED TO DISCLOSED EMBODIMENTS

[000184] The preferred forms of the invention described above are to be used as illustration only and should not be used in a limiting sense to interpret the scope of the present invention. Modifications to the exemplary embodiments, set forth above, could be readily made by those skilled in the art without departing from the spirit of the present invention.

[000185] The inventors hereby state their intent to rely on the Doctrine of Equivalents to determine and assess the reasonably fair scope of the present invention as it pertains to any apparatus not materially departing from but outside the literal scope of the invention as set forth in the following claims.

CLAIMS

What is claimed is –

1. A method for producing recycled content para-xylene (r-pX), the method comprising reforming a naphtha stream and a light recycled content pyrolysis oil (r-pyoil) stream having a T50 of less than 400°F in a reformer to produce a reformate comprising r-pX.

2. The method of claim 1, wherein at least a portion of the naphtha stream comprises one or more of:

(i) a naphtha product stream from an atmospheric distillation unit (ADU);

(ii) a hydrocracked gasoline stream;

(iii) a fluidized catalytic cracker (FCC) gasoline stream;

(iv) a raffinate from an aromatics complex; and/or

(v) a natural gasoline from a natural gas liquids (NGL) processing plant.

3. A method for producing recycled content para-xylene (r-pX), the method comprising:

(a) distilling crude oil in at least one distillation column to produce at least one naphtha stream having a T50 of less than 400°F; and

(b) reforming at least a portion of the naphtha stream and a light recycled content pyrolysis oil (r-pyoil) stream having a T50 of less than 400°F in a reformer to produce a reformate comprising r-pX,

wherein the naphtha stream and/or the light r-pyoil stream are optionally hydrotreated prior to the reforming (b).

4. A method for producing a recycled content organic chemical compound (r-organic chemical compound), the method comprising:

(a) introducing a recycled content reformate (r-reformate) stream into an aromatics complex, wherein the r-reformate stream is obtained by

distilling crude oil in at least one distillation column to produce at least one naphtha stream having a T50 of less than 400°F, and reforming at least a portion of the naphtha stream and a light recycled content pyrolysis oil (r-pyoil) stream having a T50 of less than 400°F in a reformer to produce the r-reformate stream, wherein the naphtha stream and/or the light r-pyoil stream is optionally hydrotreated prior to the reforming; and

(b) processing the r-reformate stream in the aromatics complex to provide an r-pX stream comprising at least 85 weight percent para-xylene.

5. A method for producing a recycled content organic chemical compound (r-organic chemical compound), the method comprising:

(a) introducing a stream of recycled content paraxylene (r-pX) into a terephthalic acid (TPA) production facility, wherein at least a portion of the r-pX is obtained by distilling crude oil in at least one distillation column to produce at least one naphtha stream having a T50 of less than 400°F, and reforming at least a portion of the naphtha stream and a light recycled content pyrolysis oil (r-pyoil) stream having a T50 of less than 400°F in a reformer to produce the r-reformate stream, wherein the naphtha stream and/or the light r-pyoil stream is optionally hydrotreated prior to the reforming, and processing at least a portion of the r-reformate stream in an aromatics complex to produce the r-pX; and

(b) processing at least a portion of the r-pX in the TPA production facility to provide recycled content purified terephthalic acid (r-PTA).

6. The method of any one of claims 1-5, further comprising hydrotreating at least a portion of the naphtha stream and/or at least a portion of the light r-pyoil stream before the reforming.

7. The method of claim 6, wherein at least a portion of the naphtha stream and at least a portion of the light r-pyoil stream are combined before the hydrotreating.

8. The method of any one of claims 1-5, wherein the light r-pyoil stream is not hydrotreated before the reforming (b).

9. The method of claim 8, wherein the light r-pyoil stream comprises less than 10%, less than 5%, less than 2%, less than 1%, or less than 0.1% by weight of mono-olefins and/or di-olefins.

10. The method of claim 8, wherein the light r-pyoil stream comprises less than 500 ppm, less than 250 ppm, less than 100 ppm, less than 75 ppm, less than 50 ppm, less than 25 ppm, less than 10 ppm, or less than 1 ppm of impurities, such as metals, sulfur, nitrogen, oxygen, and/or halogens.

11. The method of any one of claims 1-5, wherein the naphtha stream and/or the light r-pyoil stream has a T50 of 180 °F to 380 °F (82 °C to 193 °C).

12. The method of any one of claims 1-5, wherein at least a portion of the light r-pyoil stream that is subjected to reforming comprises:

(i) less than 500 ppm sulfur;

(ii) less than 300 ppm chlorine;

(iii) less than 500 ppm water;

(iv) less than 500 ppb arsenic; and/or

(v) less than 1500 ppm nitrogen.

13. The method of any one of claims 1-5, wherein the light r-pyoil stream is obtained by:

(i) pyrolyzing waste plastic to produce at least a recycled content pyrolysis gas (r-pygas) stream and at least a recycled content pyrolysis oil (r-pyoil) stream; and

(ii) separating the r-pyoil stream into the light r-pyoil stream and a heavy r-pyoil stream.

14. The method of claim 13, further comprising feeding at least a portion of the heavy r-pyoil stream to an atmospheric distillation unit (ADU) and/or a fluidized catalytic cracker (FCC).

15. The method of claim 14, wherein the ADU and FCC are in the same refinery.

16. The method of claim 13, wherein the light r-pyoil stream comprises predominantly C6-C10 hydrocarbons.

17. The method of claim 13, wherein the heavy r-pyoil stream comprises predominantly C11 and heavier hydrocarbons.

18. The method of any one of claims 1-5, further comprising processing at least a portion of the reformate within an aromatics complex to produce an r-pX-containing product stream, wherein the product stream comprises at least 85 weight percent para-xylene.

19. The method of claim 18, wherein the processing comprises subjecting one or more components of the reformate to at least one of a separation step, an alkylation step, a transalkylation step, a toluene disproportionation step, and an isomerization step.

20. The method of claim 19, wherein the separation step comprises one or more of an extraction step, a distillation step, a crystallization step, and/or an adsorption step.

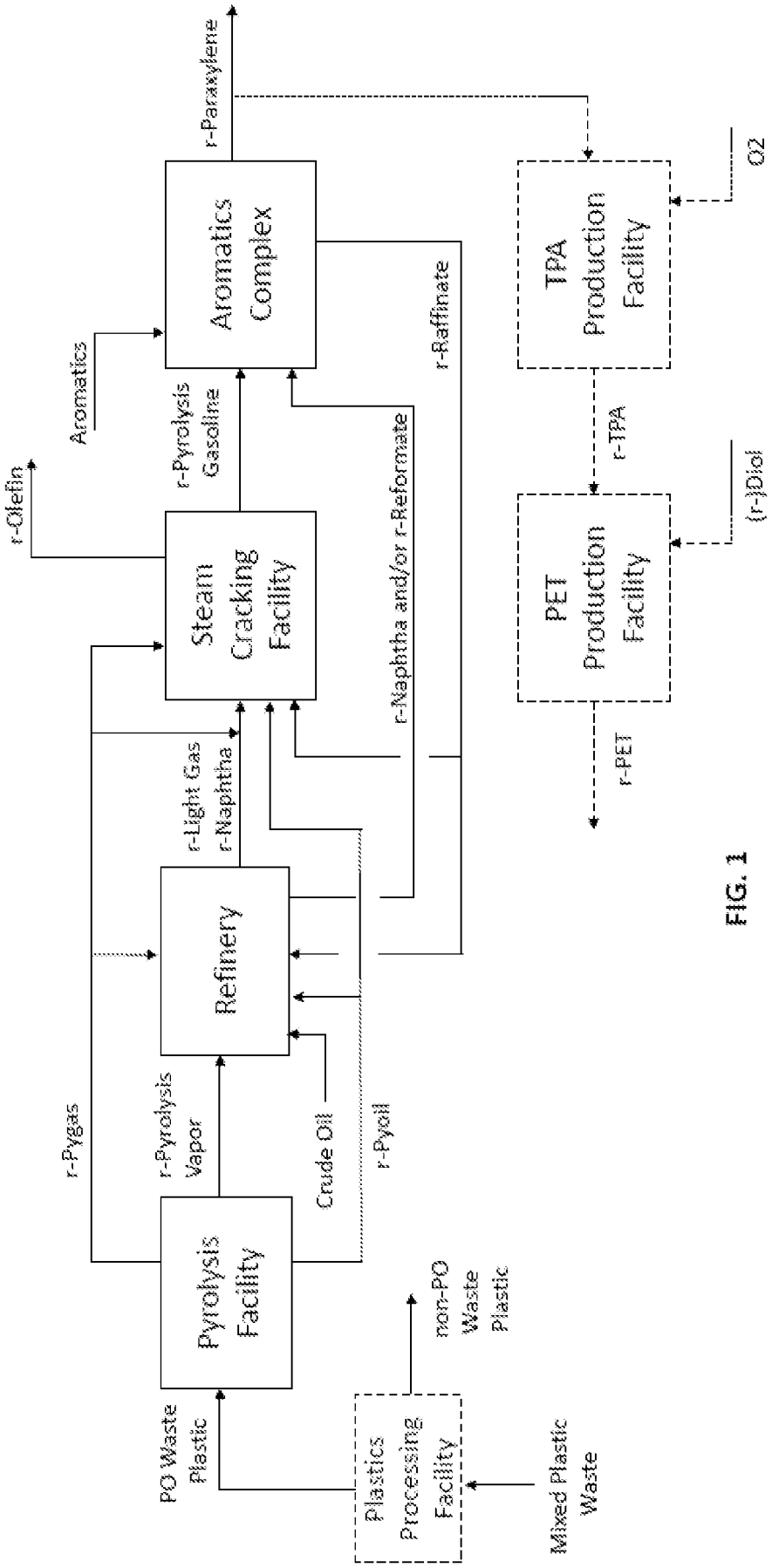

Plastics Processing Facility
PO Waste Plastic
non-PO Waste Plastic
Mixed Plastic Waste
Pyrolysis Facility
r-Pygas
r-Pyrolysis Vapor
Crude Oil
r-Pyoil
Refinery
r-Light Gas
r-Naphtha
Steam Cracking Facility
r-Olefin
Aromatics
r-Pyrolysis Gasoline
r-Naphtha and/or r-Reformate
r-Raffinate
Aromatics Complex
r-Paraxylene
TPA Production Facility
O2
r-TPA
PET Production Facility
(r-)Diol
r-PET

FIG. 1

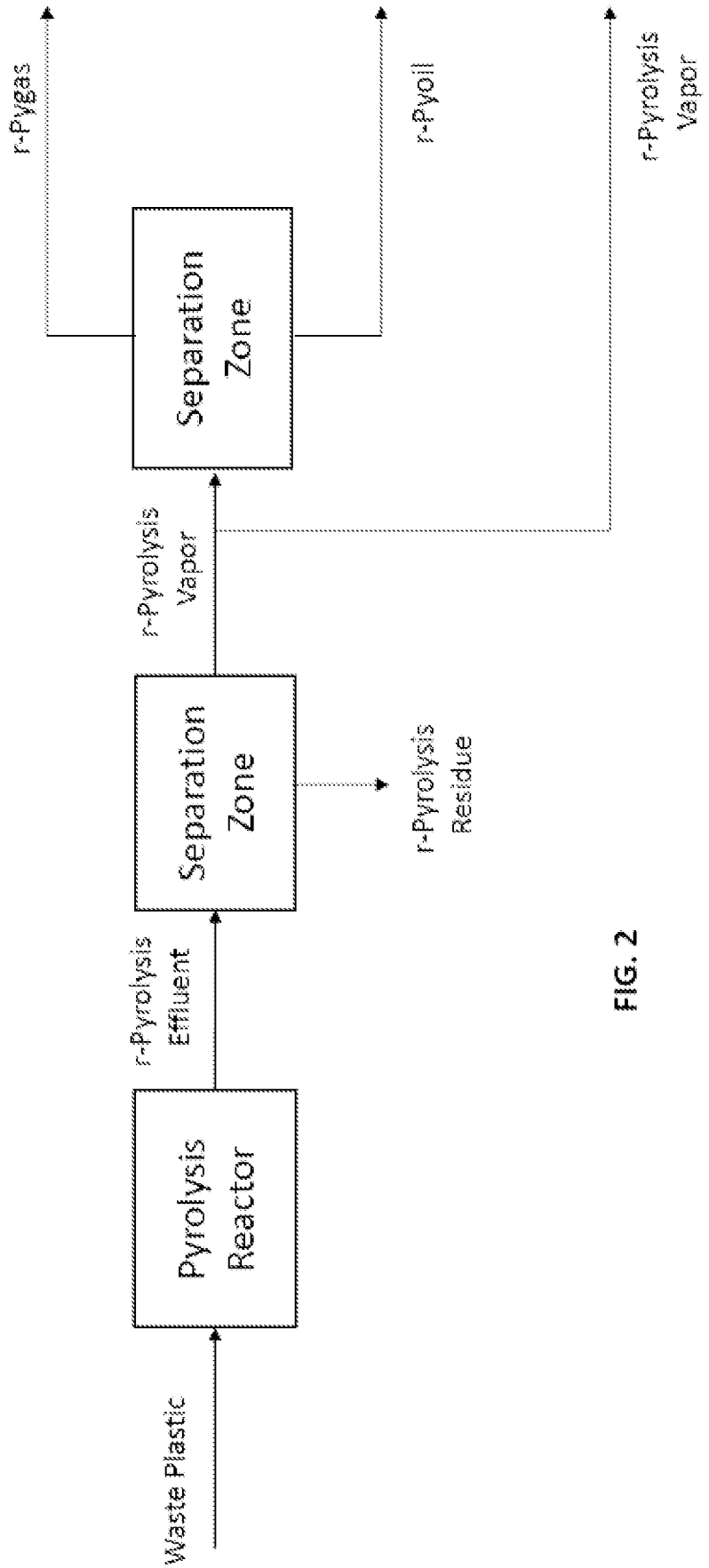

Waste Plastic
Pyrolysis Reactor
r-Pyrolysis Effluent
Separation Zone
r-Pyrolysis Residue
r-Pyrolysis Vapor
Separation Zone
r-Pygas
r-Pyoil
r-Pyrolysis Vapor

FIG. 2

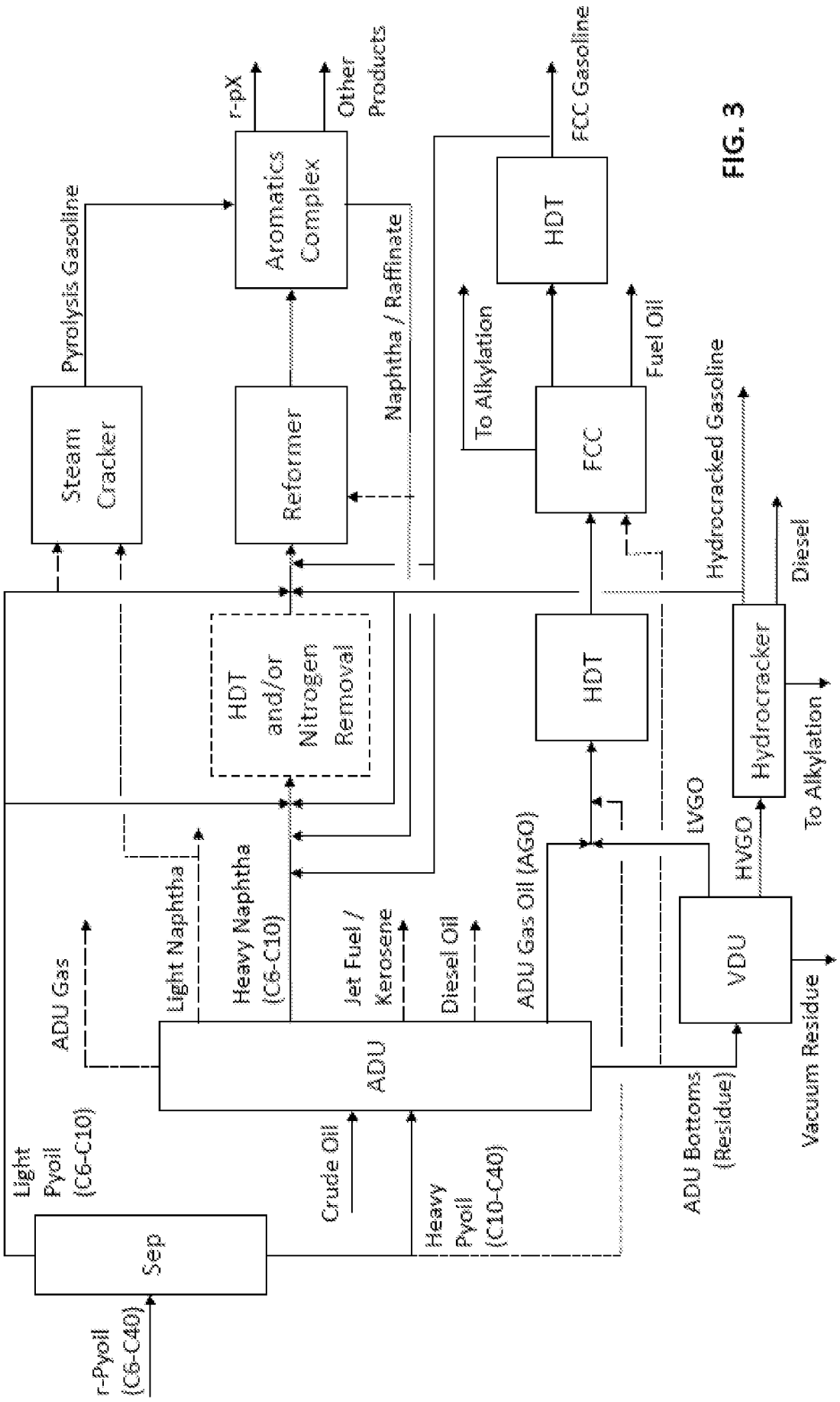

r-Pyoil (C6-C40)
Sep
Light Pyoil (C6-C10)
Crude Oil
Heavy Pyoil (C10-C40)
ADU
ADU Gas
Light Naphtha
Heavy Naphtha (C6-C10)
Jet Fuel / Kerosene
Diesel Oil
ADU Gas Oil (AGO)
ADU Bottoms (Residue)
VDU
Vacuum Residue
LVGO
HVGO
Hydrocracker
To Alkylation
Diesel
Hydrocracked Gasoline
HDT
FCC
Fuel Oil
To Alkylation
HDT
FCC Gasoline
HDT and/or Nitrogen Removal
Steam Cracker
Pyrolysis Gasoline
Reformer
Naphtha / Raffinate
Aromatics Complex
r-pX
Other Products

FIG. 3

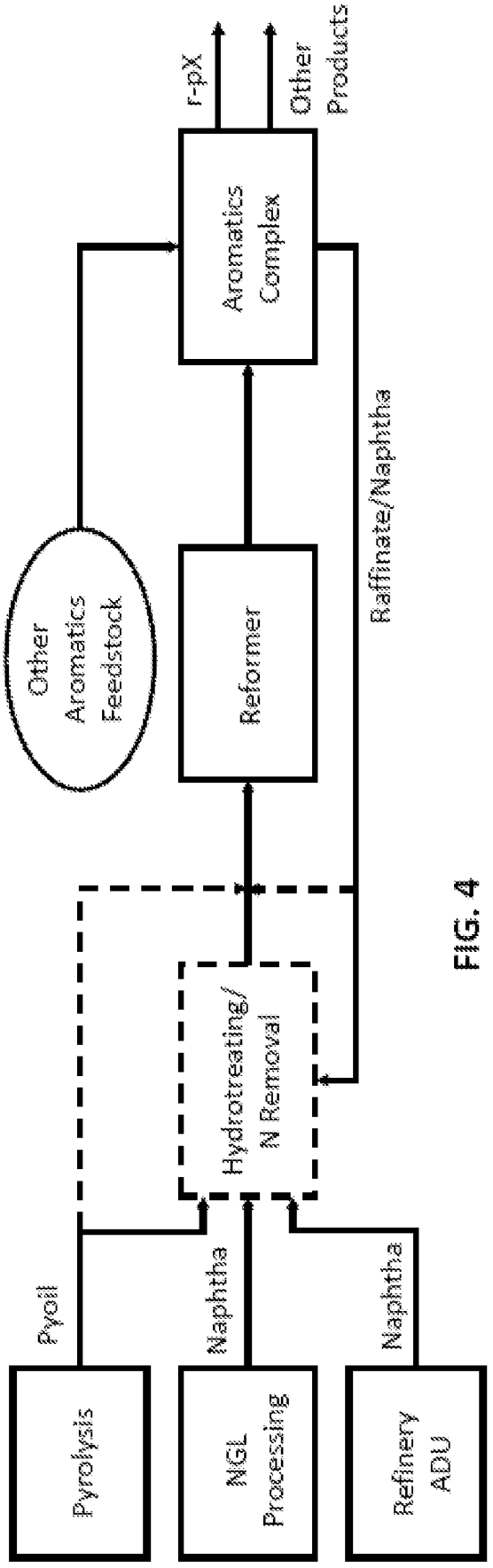

Pyrolysis
NGL Processing
Refinery ADU
Pyoil
Naphtha
Naphtha
Hydrotreating/ N Removal
Other Aromatics Feedstock
Reformer
Aromatics Complex
Raffinate/Naphtha
p-pX
Other Products

FIG. 4

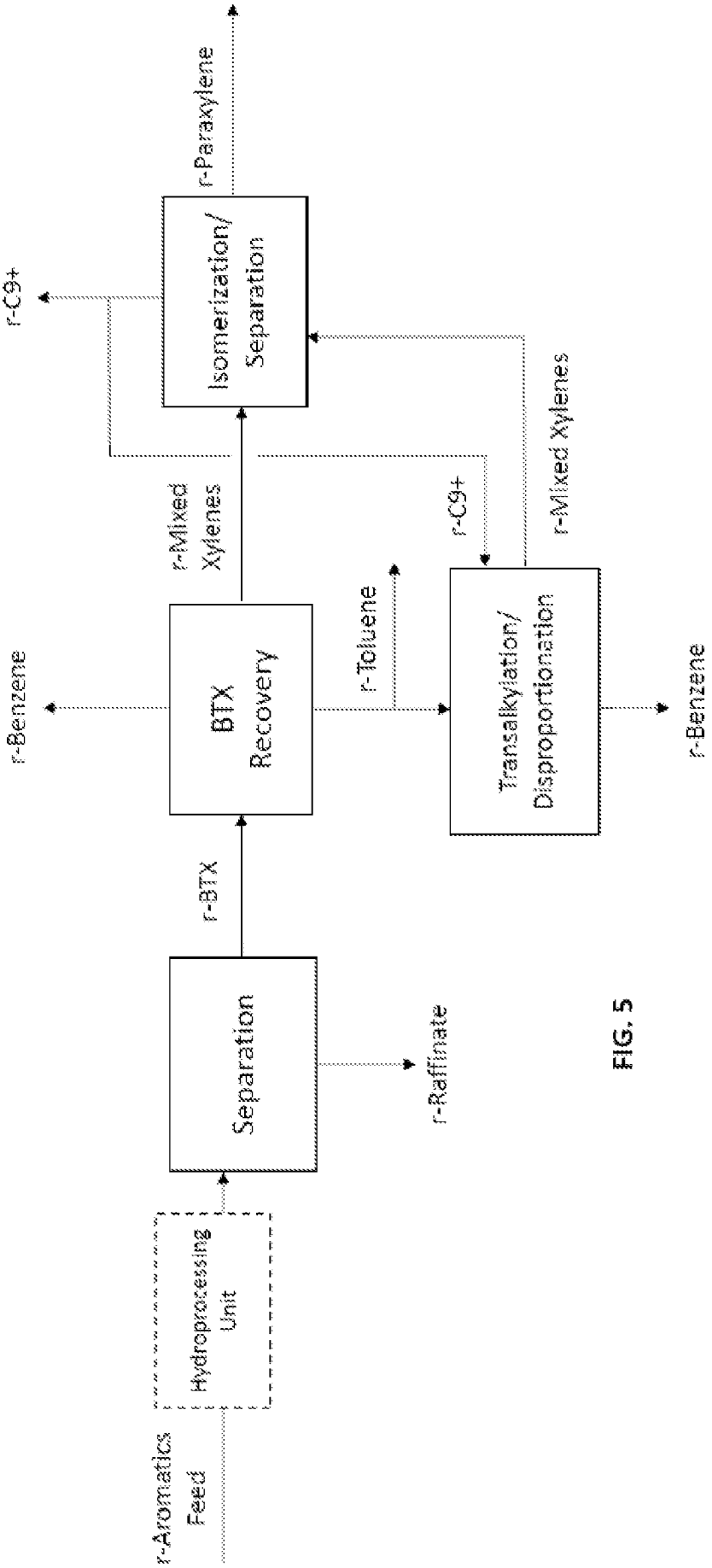

r-Aromatics Feed
Hydroprocessing Unit
Separation
r-Raffinate
r-BTX
BTX Recovery
r-Benzene
r-Mixed Xylenes
r-Toluene
r-C9+
Transalkylation/ Disproportionation
r-Benzene
r-Mixed Xylenes
Isomerization/ Separation
r-Paraxylene
r-C9+

FIG. 5

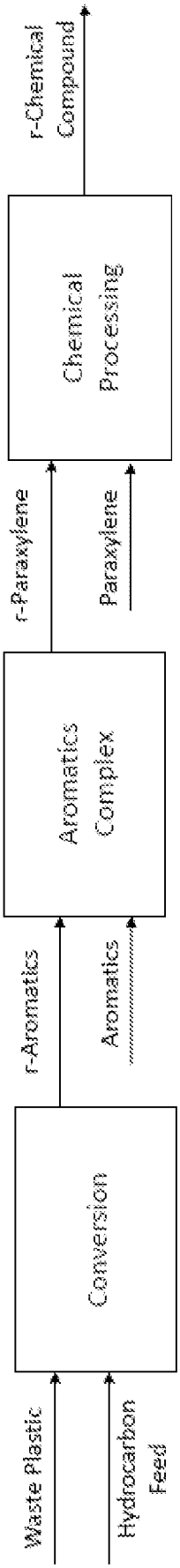

Waste Plastic
Hydrocarbon Feed
Conversion
r-Aromatics
Aromatics
Aromatics Complex
r-Paraxylene
Paraxylene
Chemical Processing
r-Chemical Compound

FIG. 6A

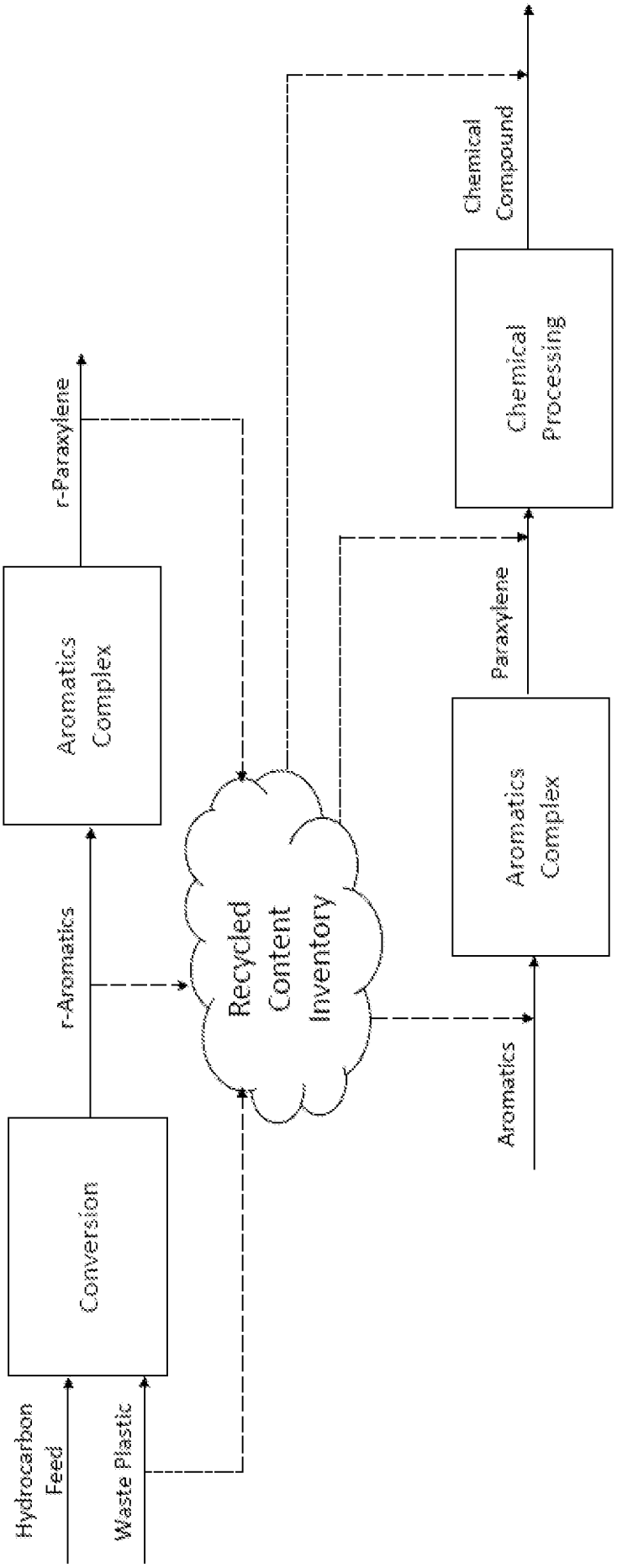

Hydrocarbon Feed
Waste Plastic
Conversion
r-Aromatics
Aromatics Complex
r-Paraxylene
Recycled Content Inventory
Aromatics
Aromatics Complex
Paraxylene
Chemical Processing
Chemical Compound

FIG. 6B

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2023/070543

A. CLASSIFICATION OF SUBJECT MATTER
INV. C10G1/10 C07C15/08 C10G35/00 C10G45/00 C10G69/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C10G C07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2022/144616 A1 (SABIC GLOBAL TECHNOLOGIES BV [NL]) 7 July 2022 (2022-07-07) figures 1-5 paragraph [0033] - paragraph [0061]; tables 1-4	1-20
X	US 2020/017773 A1 (RAMAMURTHY KRISHNA KUMAR [IN] ET AL) 16 January 2020 (2020-01-16) paragraph [0010] - paragraph [0099]; tables 1-4 figures 1-3	1-20
A	EP 3 744 814 A1 (BIOBTX B V [NL]) 2 December 2020 (2020-12-02) paragraph [0008] - paragraph [0069] figures 1-3	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 November 2023	27/11/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bernet, Olivier

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2023/070543

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		EP 3744814 A1	02-12-2020