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(54) **Title:** PROCESS FOR CONVERTING POLYCYCLIC AROMATIC COMPOUNDS TO MONOCYCLIC AROMATIC COMPOUNDS

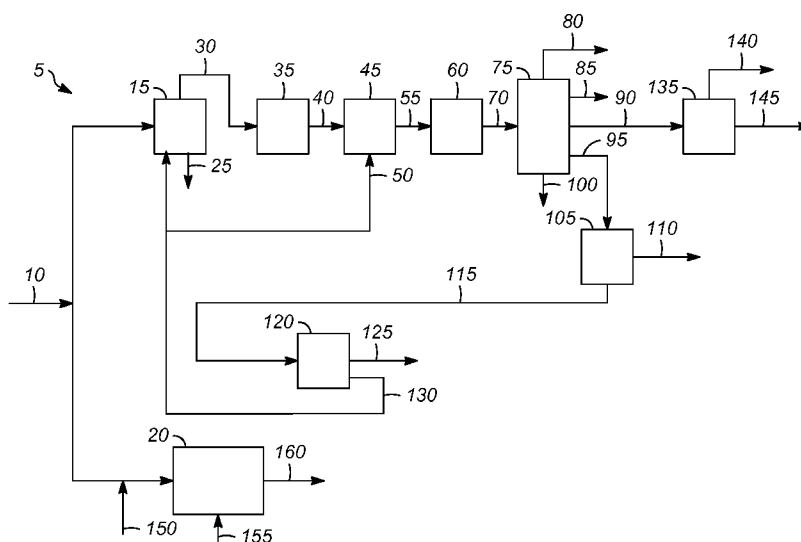


FIG. 1

(57) **Abstract:** A process for converting polycyclic aromatic compounds to monocyclic aromatic compounds includes pyrolyzing a coal feed to produce a coke stream and a coal tar stream. The coal tar stream is cracked, and the cracked coal tar stream is fractionated to produce an aromatic fraction comprising the polycyclic aromatic compounds. The process further includes hydrocracking the aromatic fraction to partially hydrogenate at least a first portion of the aromatic fraction, and to open at least one ring of a second portion of the aromatic fraction to form the monocyclic aromatic compounds from the polycyclic compounds, and recycling the first portion of the aromatic fraction.



PROCESS FOR CONVERTING POLYCYCLIC AROMATIC COMPOUNDS TO
MONOCYCLIC AROMATIC COMPOUNDS

STATEMENT OF PRIORITY

5 This application claims priority to U.S. Provisional Application No. 61/906,077 filed on November 19, 2013, the contents of which are hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

10 Many different types of chemicals are produced from the processing of petroleum. However, petroleum is becoming more expensive because of increased demand in recent decades.

15 Therefore, attempts have been made to provide alternative sources for the starting materials for manufacturing chemicals. Attention is now being focused on producing liquid hydrocarbons from solid carbonaceous materials, such as coal, which is available in large quantities in countries such as the United States and China.

 Pyrolysis of coal produces coke and coal tar. The coke-making or "coking" process consists of heating the material in closed vessels in the absence of oxygen to very high temperatures. Coke is a porous but hard residue that is mostly carbon and inorganic ash, which can be used in making steel.

20 Coal tar is the volatile material that is driven off during heating, and it comprises a mixture of a number of hydrocarbon compounds. It can be separated to yield a variety of organic compounds, such as benzene, toluene, xylene, naphthalene, anthracene, and phenanthrene. These organic compounds can be used to make numerous products, for example, dyes, drugs, explosives, flavorings, perfumes, preservatives, synthetic resins, and
25 paints and stains. The residual pitch left from the separation is used for paving, roofing, waterproofing, and insulation.

30 Coal tar includes a wide variety of aromatic compounds, including both polycyclic and monocyclic aromatic compounds. However, monocyclic aromatic compounds have broader applicability, and thus more value as end products when compared to polycyclic aromatic compounds.

 Thus, there is a need for a process for converting polycyclic aromatic compounds to monocyclic aromatic compounds.

SUMMARY OF THE INVENTION

In a first aspect, a process for converting polycyclic aromatic compounds to monocyclic aromatic compounds includes pyrolyzing a coal feed to produce a coke stream and a coal tar stream. The coal tar stream is cracked, and the cracked coal tar stream is fractionated to produce an aromatic fraction comprising the polycyclic aromatic compounds.

5 The process further includes hydrocracking the aromatic fraction to partially hydrogenate at least a first portion of the aromatic fraction, and to open at least one ring of a second portion of the aromatic fraction to form the monocyclic aromatic compounds from the polycyclic compounds, and recycling the first portion of the aromatic fraction.

In another aspect, a process for converting polycyclic aromatics to monocyclic aromatics includes pyrolyzing a coal feed to produce a coke stream and a coal tar stream.

10 The process further includes cracking the coal tar stream and fractionating the cracked coal tar stream to produce an aromatic fraction comprising naphthalene and alkylnaphthalenes. The aromatic fraction is hydrocracked to partially hydrogenate at least a first portion of the aromatic fraction, and to open one ring of a second portion of the aromatic fraction, and the

15 first portion of the aromatic fraction is recycled.

BRIEF DESCRIPTION OF THE DRAWING

The Figure is an illustration of one embodiment of the process of the present invention for converting polycyclic aromatics to monocyclic aromatics.

DETAILED DESCRIPTION OF THE INVENTION

20 The Figure shows one embodiment of a coal conversion process 5 of the present invention. A coal feed 10 can be sent to a pyrolysis zone 15, such as a coking oven, or a gasification zone 20. Alternatively, the coal feed 10 can be split into two parts and sent to both the pyrolysis zone 15 and the gasification zone 20.

In the pyrolysis zone 15, the coal is heated at high temperature, e.g., up to

25 2,000°C (3,600°F), in the absence of oxygen to drive off the volatile components. Coking produces coke 25 and coal tar stream 30. The coke 25 can be used in other processes, such as the manufacture of steel.

The coal tar stream 30 which comprises the volatile components from the coking process can be sent to an optional contamination removal zone 35, if desired.

The contaminant removal zone 35 for removing one or more contaminants from the coal tar stream 30 or another process stream may be located at various positions along the process depending on the impact of the particular contaminant on the product or process and the reason for the contaminant's removal, as described further below. For example, the contaminant removal zone 35 can be positioned upstream of a separation zone 75. Some contaminants have been identified to interfere with a downstream processing step or hydrocarbon conversion process, in which case the contaminant removal zone 35 may be positioned upstream of the separation zone 75 or between the separation zone 75 and the particular downstream processing step at issue. Still other contaminants have been identified that should be removed to meet particular product specifications. Where it is desired to remove multiple contaminants from the hydrocarbon or process stream, various contaminant removal zones 35 may be positioned at different locations along the process. In still other approaches, a contaminant removal zone 35 may overlap or be integrated with another process within the system, in which case the contaminant may be removed during another portion of the process, including, but not limited to the separation zone 75 or the downstream hydrocarbon conversion zone. This may be accomplished with or without modification to these particular zones, reactors or processes. While the contaminant removal zone 35 is often positioned downstream of the hydrocarbon conversion reactor, it should be understood that the contaminant removal zone 35 in accordance herewith may be positioned upstream of the separation zone 75, between the separation zone 75 and the hydrocarbon conversion zone, or downstream of the hydrocarbon conversion zone or along other streams within the process stream, such as, for example, a carrier fluid stream, a fuel stream, an oxygen source stream, or any streams used in the systems and the processes described herein. The contaminant concentration is controlled by removing at least a portion of the contaminant from the coal tar stream 35. As used herein, the term removing may refer to actual removal, for example by adsorption, absorption, or membrane separation, or it may refer to conversion of the contaminant to a more tolerable compound, or both.

The decontaminated coal tar feed 40 is sent to an optional hydrotreating zone 45. Hydrotreating is a process in which hydrogen donor molecules 50 are contacted with a hydrocarbon stream in the presence of suitable catalysts which are primarily active for the removal of heteroatoms, such as sulfur, nitrogen, and oxygen, and metals from the hydrocarbon feedstock. In hydrotreating, hydrocarbons with double and triple bonds may be

saturated. The hydrogen donor molecules 50 can include, for example, hydrogen gas, water, ammonia, hydrogenated aromatic compounds, or any combination thereof. Aromatics may also be saturated. Typical hydrotreating reaction conditions include a temperature of 290°C (550°F) to 455°C (850°F), a pressure of 3.4 MPa (500 psig) to 6.2 MPa (900 psig), a liquid
5 hourly space velocity of 0.5 hr^{-1} to 4 hr^{-1} , and a hydrogen rate of 168 to 1,011 Nm^3/m^3 oil (1,000-6,000 scf/bbl). Typical hydrotreating catalysts include at least one Group VIII metal, preferably iron, cobalt and nickel, and at least one Group VI metal, preferably molybdenum and tungsten, on a high surface area support material, preferably alumina. Other typical hydrotreating catalysts include zeolitic catalysts, as well as noble metal catalysts where the
10 noble metal is selected from palladium and platinum. The hydrotreated coal tar stream 55 from the hydrotreating zone 45 is routed to a cracking zone 60.

In the cracking zone 60, the hydrotreated coal tar stream 55 is contacted with one or more cracking catalysts to crack hydrocarbons and produce lower molecular weight hydrocarbons. The cracking zone 60 may comprise, for example, a hydrocracking zone, a
15 fluid catalytic cracking zone, or a thermal cracking zone as are known in the art.

Hydrocracking is a process in which hydrocarbons crack in the presence of hydrogen to lower molecular weight hydrocarbons. Typical hydrocracking conditions may include a temperature of 290°C (550°F) to 468°C (875°F), a pressure of 3.5 MPa (500 psig) to 27.58 MPa (4,000 psig), a liquid hourly space velocity (LHSV) of 0.5 to less than 5 hr^{-1} , and a
20 hydrogen rate of 421 to 2,527 Nm^3/m^3 oil (2,500-15,000 scf/bbl). Typical hydrocracking catalysts include amorphous silica-alumina bases or low-level zeolite bases combined with one or more Group VIII or Group VIB metal hydrogenating components, or a crystalline zeolite cracking base upon which is deposited a Group VIII metal hydrogenating component. Additional hydrogenating components may be selected from Group VIB for incorporation with
25 the zeolite base.

Fluid catalytic cracking (FCC) is a catalytic hydrocarbon conversion process accomplished by contacting heavier hydrocarbons in a fluidized reaction zone with a catalytic particulate material. The reaction in catalytic cracking is carried out in the absence of substantial added hydrogen or the consumption of hydrogen. The process typically employs a
30 powdered catalyst having the particles suspended in a rising flow of feed hydrocarbons to form a fluidized bed. In representative processes, cracking takes place in a riser, which is a vertical or upward sloped pipe. Typically, a pre-heated feed is sprayed into the base of the

riser via feed nozzles where it contacts hot fluidized catalyst and is vaporized on contact with the catalyst, and the cracking occurs converting the high molecular weight oil into lighter components including liquefied petroleum gas (LPG), gasoline, and a distillate. The catalyst-feed mixture flows upward through the riser for a short period (a few seconds), and then the mixture is separated in cyclones. The hydrocarbons are directed to a fractionator for separation into LPG, gasoline, diesel, kerosene, jet fuel, and other possible fractions. While going through the riser, the cracking catalyst is deactivated because the process is accompanied by formation of coke which deposits on the catalyst particles. Contaminated catalyst is separated from the cracked hydrocarbon vapors and is further treated with steam to remove hydrocarbon remaining in the pores of the catalyst. The catalyst is then directed into a regenerator where the coke is burned off the surface of the catalyst particles, thus restoring the catalyst's activity and providing the necessary heat for the next reaction cycle. The process of cracking is endothermic. The regenerated catalyst is then used in the new cycle. Typical FCC conditions include a temperature of 400°C to 800°C, a pressure of 0 to 688 kPag (0 to 100 psig), and contact times of 0.1 seconds to 1 hour. The conditions are determined based on the hydrocarbon feedstock being cracked, and the cracked products desired. Zeolite-based catalysts are commonly used in FCC reactors, as are composite catalysts which contain zeolites, silica-aluminas, alumina, and other binders.

The hydrocracked stream 70 is routed to a separation zone 75 where it is separated into two or more fractions 80, 85, 90, 85, 100. Coal tar comprises a complex mixture of heterocyclic aromatic compounds and their derivatives with a wide range of boiling points. The number of fractions and the components in the various fractions can be varied as is well known in the art. A typical separation process involves separating the coal tar into four to six streams. For example, there can be a fraction comprising NH₃, CO, and light hydrocarbons, a light oil fraction with boiling points between 0°C and 180°C, a middle oil fraction with boiling points between 180°C to 230°C, a heavy oil fraction with boiling points between 230 to 270°C, an anthracene oil fraction with boiling points between 270°C to 350°C, and pitch.

The light oil fraction contains compounds such as benzene, toluene, xylenes, naphtha, coumarone-indene, dicyclopentadiene, pyridine, and picoline. The middle oil fraction contains compounds such as phenols, cresols and cresylic acids, xylenols, naphthalene, high boiling tar acids, and high boiling tar bases. The heavy oil fraction

contains benzene absorbing oil and creosotes. The anthracene oil fraction contains anthracene. Pitch is the residue of the coal tar distillation containing primarily aromatic hydrocarbons and heterocyclic compounds.

As illustrated, the hydrocracked coal tar stream 70 is separated into gas fraction 80 containing gases such as NH_3 and CO as well as light hydrocarbons, such as ethane, hydrocarbon fractions 85, 90, and 95 having different boiling point ranges, and pitch fraction 100. Suitable separation processes include, but are not limited to fractionation, solvent extraction, or adsorption.

One or more of the fractions 80, 85, 90, 95, 100 can be further processed, as desired. As illustrated, the fraction 95 is sent to an optional aromatic concentration zone 105. Preferably, the fraction 95 includes hydrocarbons that have an initial boiling point in the range of 170°C to 300°C , and includes at least polycyclic aromatic hydrocarbons such as naphthalene and alkylnaphthalenes. Various known concentration processes such as distillation or crystallization of the fraction 95 can be used to produce a concentrated aromatics stream 115 having a relatively high concentration of polycyclic aromatic compounds. For example, the aromatics stream 115 may include around 30% to 40% by volume of polycyclic aromatic compounds. An effluent stream 110 including compounds removed by the concentration may be subject to additional downstream processing as desired.

The aromatics stream 115 is routed to a hydrocracking zone 120 to undergo a hydrocracking process. As discussed above, the hydrocracking process cracks hydrocarbons in the presence of hydrogen to form lower molecular weight hydrocarbons. Typical hydrocracking conditions may include a temperature of 290°C (550°F) to 468°C (875°F), a pressure of 3.5 MPa (500 psig) to 20.7 MPa (3,000 psig), a liquid hourly space velocity (LHSV) of 1.0 to less than 2.5 hr^{-1} , and a hydrogen rate of 421 to $2,527\text{ Nm}^3/\text{m}^3\text{ oil}$ (2,500-15,000 scf/bbl). One or more hydrocracking catalysts include amorphous silica-alumina bases or low-level zeolite bases combined with one or more Group VIII or Group VIB metal hydrogenating components, or a crystalline zeolite cracking base upon which is deposited a Group VIII metal hydrogenating component. The zeolitic cracking base can have a mesoporous structure, having pore sizes in the range of 2 nm to 50 nm. Additional hydrogenating components may be selected from Group VIB for incorporation with the zeolite base. In particular, the metal used in the hydrocracking catalyst includes one or more of nickel, molybdenum, and tungsten.

During the hydrocracking process, a first portion of the polycyclic aromatic compounds present in the aromatics stream 115 are hydrogenated. Hydrogenation involves the addition of hydrogen to hydrogenatable hydrocarbon compounds. Alternatively, hydrogen can be provided in a hydrogen-containing compound with readily available hydrogen, such as tetralin, alcohols, hydrogenated naphthalenes, and others via a transfer hydrogenation process with or without a catalyst. The hydrogenatable hydrocarbon compounds (that is, the naphthalene and alkyl naphthalenes present in aromatics stream 115) are contacted with a hydrogen-rich gaseous phase and a hydrogenation catalyst in order to hydrogenate at least a portion of the hydrogenatable hydrocarbon compounds to form hydrogenated hydrocarbon compounds including tetralin and alkyl tetralins, which can be used as hydrogen donor molecules. The hydrogenated hydrocarbons are output as a stream 130. The hydrogenated hydrocarbons stream 130 may be used to supply hydrogen to an upstream process, or to supplement an existing hydrogen supply. For example, the hydrogenated hydrocarbons stream 130 may be provided to one or both of the pyrolysis zone 15 and the hydrotreating zone 45. When provided to the hydrotreating zone 45, the stream 130 serves as the hydrogen donor stream 50. When the hydrogenated hydrocarbons stream 130 is recycled to the pyrolysis zone 15, the hydrogenated hydrocarbons provide hydrogen donor molecules to pyrolysis, thereby producing a hydrogen-enriched coal tar stream. While the Figure shows the hydrogenated hydrocarbons stream 130 recycled to both the pyrolysis zone 15 and the hydrotreating zone 45, it will be appreciated by those of skill in the art that the hydrogenated hydrocarbons stream 130 could alternatively be provided to only one of the pyrolysis zone 15 and the hydrotreating zone 45 without departing from the scope of the invention.

Returning to the hydrocracking zone 120, a second portion of the polycyclic aromatic compounds present in the concentrated stream 115 are cracked, causing at least one aromatic ring to “open,” or break, thereby forming monocyclic aromatic compounds. The monocyclic aromatic compounds are output from the hydrocracking zone 120 as a monocyclic aromatic stream 125, and may be subject to further downstream processing, as desired. For example, the monocyclic aromatic stream 125 may undergo downstream transalkylation, alkylation, distillation, isomerization, to control the concentrations of benzene and alkylbenzenes present in the monocyclic aromatic stream 125. For example, it may be desirable to increase a concentration of xylenes in the monocyclic aromatic stream

125, or to increase concentration of one or more particular xylene isomers (i.e., para-xylene, meta-xylene, and/or ortho-xylene).

The transalkylation reaction can be effected in contact with a catalytic composite in any conventional or otherwise convenient manner and may comprise a batch or continuous type of operation, with a continuous operation being preferred. The transalkylation catalyst is usefully disposed as a fixed bed in a reaction zone of a vertical tubular reactor, with the alkylaromatic feed stock charged through the bed in an upflow or downflow manner. The transalkylation zone normally operates at conditions including a temperature in the range of 130°C to 540°C. The transalkylation zone is typically operated at moderately elevated pressures broadly ranging from 100 kPa to 10 MPa absolute. The transalkylation reaction can be effected over a wide range of space velocities. That is, volume of charge per volume of catalyst per hour; weight hourly space velocity (WHSV) generally is in the range of from 0.1 to 30hr⁻¹. The catalyst is typically selected to have relatively high stability at a high activity level.

For petrochemicals, the alkylation reaction can be performed using an aromatic compound such as benzene or toluene. When using benzene and alkylating with a light olefin such as ethylene or propylene, the product is typically ethylbenzene or cumene. These products can be converted to styrene or phenol plus acetone. When toluene is alkylated with propylene, cymene isomers can be produced, which could be converted into cresols. Aromatic alkylation is generally now conducted with solid acid catalysts including zeolites or amorphous silica-aluminas or ionic liquid catalyst in liquid phase, or alternatively a zeolitic catalyst in vapor phase.

For at least alkylation of aromatic compounds, the temperature range is from 100°C to 225°C at the pressure range of 200 kPa to 7100 kPa in liquid phase, or higher temperature in vapor phase.

Returning to the separation zone 75,, a stream 90 including aliphatic C₆-hydrocarbons is separated during the separation process in the separation zone 75. The aliphatic C₆-hydrocarbons stream 90 is routed to a steam cracking zone 135. Steam cracking is a process in which saturated hydrocarbons are broken down into smaller, often unsaturated, hydrocarbons. It is the principal industrial method for producing the olefins, including ethylene and propylene. The aliphatic C₆-hydrocarbons stream 90 is contacted with steam and briefly heated in a furnace without the presence of oxygen. Typically, the reaction

temperature is very high, at around 850°C, but the reaction is only allowed to take place very briefly. In modern cracking furnaces, the residence time can be reduced to milliseconds to improve yield. After the cracking temperature has been reached, the gas is quickly quenched to stop the reaction in a transfer line heat exchanger or inside a quenching header using quench oil. The steam cracking process results in output of a hydrogen stream 140 as well as an olefins stream 145. The hydrogen stream 140 may be recycled to various upstream processes or provided to downstream processes as a hydrogen donor. The olefin stream 145 may be collected as an end product of the process or subject to further downstream processing as desired.

In some processes, all or a portion of the coal feed 10 is mixed with oxygen 150 and steam 155 and reacted under heat and pressure in the gasification zone 20 to form syngas 160, which is a mixture of carbon monoxide and hydrogen. The syngas 160 can be further processed using the Fischer-Tropsch reaction to produce gasoline or using the water-gas shift reaction to produce more hydrogen.

SPECIFIC EMBODIMENTS

While the following is described in conjunction with specific embodiments, it will be understood that this description is intended to illustrate and not limit the scope of the preceding description and the appended claims.

A first embodiment of the invention is a process for converting polycyclic aromatic compounds to monocyclic aromatic compounds comprising pyrolyzing a coal feed to produce a coke stream and a coal tar stream; cracking the coal tar stream; fractionating the cracked coal tar stream to produce an aromatic fraction comprising the polycyclic aromatic compounds; hydrocracking the aromatic fraction to partially hydrogenate at least a first portion of the aromatic fraction, and to open at least one ring of a second portion of the aromatic fraction to form the monocyclic aromatic compounds from the polycyclic compounds; recycling the first portion of the aromatic fraction. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the first portion of the aromatic fraction is recycled to the pyrolyzing of the coal tar stream. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, further comprising hydrotreating the coal tar stream to remove one or more of nitrogen,

sulfur, and oxygen contaminants from the coal tar stream, and wherein the cracking step cracks the hydrotreated coal tar stream. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the first portion of the aromatic fraction is recycled to the hydrotreating. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the aromatic fraction comprises aromatic hydrocarbons having an initial boiling point from 170°C to 300°C. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the polycyclic aromatic compounds comprise naphthalene and alkylnaphthalenes, and wherein the first portion comprises tetralin and alkyltetralins. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, further comprising increasing a concentration of the polycyclic aromatic compounds in the aromatic fraction. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the step of increasing the concentration comprises distilling the aromatic fraction. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the step of increasing the concentration increases the concentration of the polycyclic aromatic compounds in the concentrated aromatic fraction to a range of 30% to 40%. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the hydrocracking comprises contacting the aromatic fraction with a zeolitic catalyst including a metal function. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the metal function includes one or more of nickel, molybdenum, and tungsten. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the fractionating further produces an aliphatic stream comprising C6- aliphatic hydrocarbons. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, further comprising steam cracking the aliphatic stream to produce one or more of ethylene and propylene. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up

through the first embodiment in this paragraph, wherein the step of steam cracking further produces hydrogen.

A second embodiment of the invention is a process for converting polycyclic aromatics to monocyclic aromatics comprising pyrolyzing a coal feed to produce a coke stream and a coal tar stream; cracking the coal tar stream; fractionating the cracked coal tar stream to produce an aromatic fraction comprising naphthalene and alkylnaphthalenes; hydrocracking the aromatic fraction to partially hydrogenate at least a first portion of the aromatic fraction, and to open one ring of a second portion of the aromatic fraction; recycling the first portion of the aromatic fraction. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph, wherein the first portion of the aromatic fraction is recycled to the pyrolyzing of the coal tar stream. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph, wherein the hydrocracking comprises contacting the aromatic fraction with a zeolitic catalyst including a metal function. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph, wherein the zeolitic catalyst has a mesoporous structure. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph, further comprising hydrotreating the coal tar stream to remove one or more of nitrogen, sulfur, and oxygen contaminants from the coal tar stream, and wherein the cracking step cracks the hydrotreated coal tar stream. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph, wherein the first portion of the aromatic fraction is recycled to the hydrotreating.

While at least one exemplary embodiment has been presented in the foregoing detailed description of the invention, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention. It being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope of the invention as set forth in the appended claims.

CLAIMS:

1. A process for converting polycyclic aromatic compounds to monocyclic aromatic compounds comprising:

5 pyrolyzing a coal feed (10) to produce a coke stream (25) and a coal tar stream (30);

 cracking the coal tar stream (30);

 fractionating the cracked coal tar stream (30) to produce an aromatic fraction (95) comprising polycyclic aromatic compounds;

10 hydrocracking the aromatic fraction (95) to partially hydrogenate at least a first portion (130) of the aromatic fraction, and to open at least one ring of a second portion (125) of the aromatic fraction to form the monocyclic aromatic compounds from the polycyclic aromatic compounds;

 recycling the first portion (130) of the aromatic fraction.

15 2. The process of claim 1, wherein the first portion (130) of the aromatic fraction is recycled to the pyrolyzing of the coal feed (10).

20 3. The process of claim 1, further comprising hydrotreating the coal tar stream (30) to remove one or more of nitrogen, sulfur, and oxygen contaminants from the coal tar stream, and wherein said cracking step cracks the hydrotreated coal tar stream (55).

 4. The process of claim 3, wherein the first portion of the aromatic fraction (130) is recycled to the hydrotreating of the coal tar stream (30).

25 5. The process of any one of claims 1 to 4, wherein the aromatic fraction (95) comprises aromatic hydrocarbons having an initial boiling point from 170°C to 300°C.

30 6. The process of any one of claims 1 to 4, wherein the polycyclic aromatic compounds comprise naphthalene and alkyl naphthalenes, and wherein the first portion (130) comprises tetralin and alkyl tetralins.

7. The process of any one of claims 1 to 4, further comprising:
increasing a concentration of the polycyclic aromatic compounds in the
aromatic fraction (95).

5

8. The process of any one of claims 1 to 4, wherein said hydrocracking
comprises:

contacting the aromatic fraction (95) with a zeolitic catalyst including a metal
function, wherein said metal function includes one or more of nickel, molybdenum, and
tungsten.

10

9. The process of any one of claims 1 to 4, wherein said fractionating
further produces an aliphatic stream (90) comprising C₆- aliphatic hydrocarbons.

15

10. The process of claim 9, further comprising:
steam cracking the aliphatic stream (90) to produce one or more of ethylene
and propylene (145).

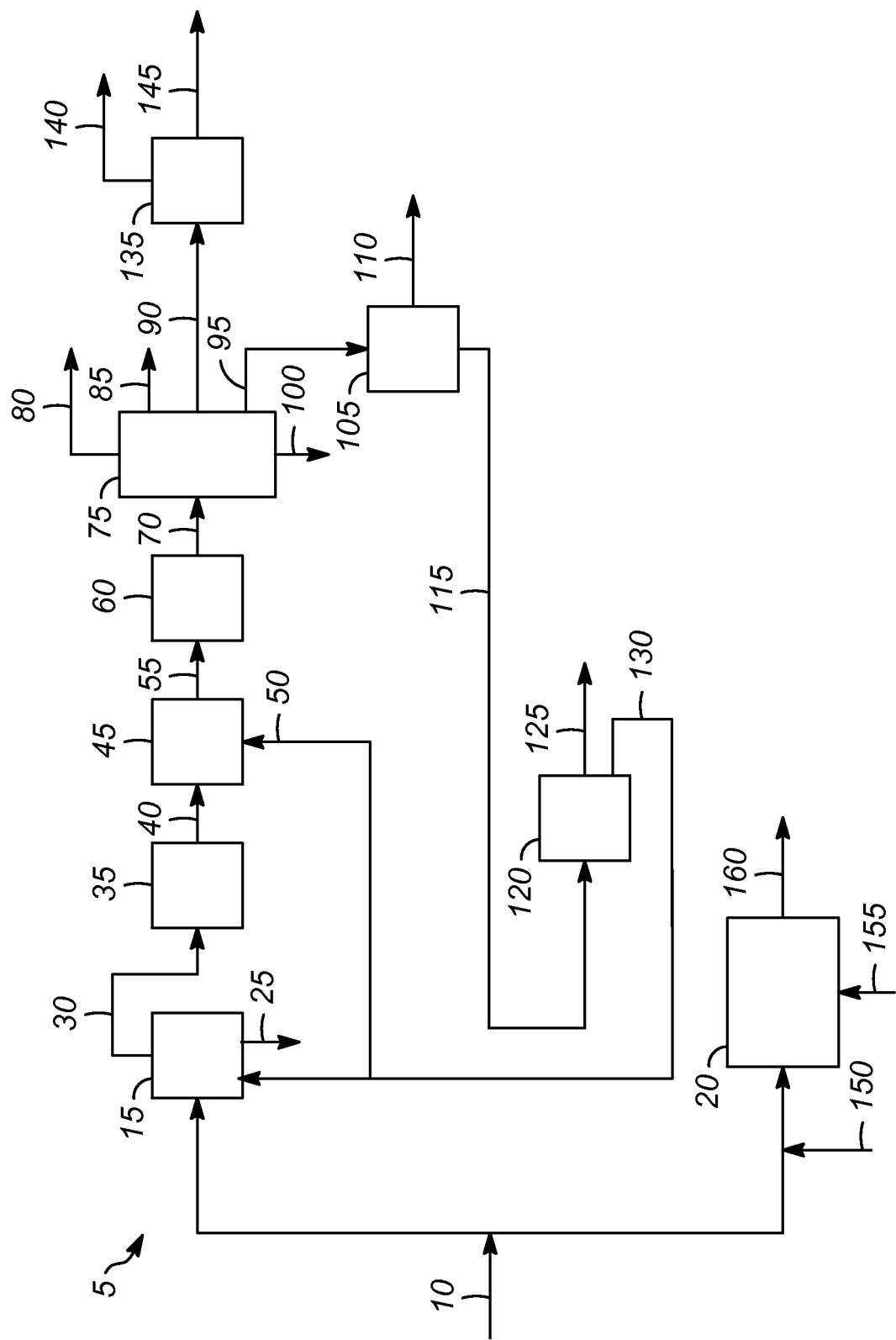


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/065395**A. CLASSIFICATION OF SUBJECT MATTER****C07C 4/04(2006.01)i, C07C 7/00(2006.01)i**

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)

C07C 4/04; C07C 120; C07C 15/02; C07C 5/02; C07C 5/00; B01J 29/76; C10G 1/04; C07C 1/00; B01J 29/78; C07C 7/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: polycyclic aromatic compound, monocyclic aromatic compound, coal, coal tar, hydrocracking

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013-0267744 A1 (HONG CHAN KIM et al.) 10 October 2013 See the abstract; fig. 1; [0021]-[0024]; examples 1, 2.	1-10
A	US 04097541 A (SAKAI, TOMOYA et al.) 27 June 1978 See the abstract; column 1, line 59- column 2, line 54; column 5, line 64- column 6, line 3.	1-10
A	US 03966584 A (GRAY, MICHAEL DAVID et al.) 29 June 1976 See the abstract; column 1, lines 49-53; examples 1-5; and claim 4.	1-10
A	US 04983782 A (MERZ LUDWIG et al.) 08 January 1991 See the abstract; claims 1-24.	1-10
A	WO 2012-053853 A2 (SK INNOVATION CO., LTD. et al.) 26 April 2012 See the abstract.	1-10
A	METTA CHAREONPANICH et al., 'Effect of catalysts on yields of monocyclic aromatic hydrocarbons in hydrocracking of coal volatile matter', Fuel, 1995, Vol. 74(11), pp. 1636-1640 See the abstract.	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

23 January 2015 (23.01.2015)

Date of mailing of the international search report

02 February 2015 (02.02.2015)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2014/065395

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Miki, Y. et al, `Hydrocracking of polycyclic aromatic compounds. 1. Methylnaphthalenes`, Fuel Processing Technology, 1995, Vol. 43, pp. 137-146 See the abstract.	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

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