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(54) Title: IMPROVED YIELDS IN XYLENE ISOMERIZATION USING LAYER MFI ZEOLITES

(57) Abstract: A process for the production of para-xylene is presented. The process includes the isomerization of C8 aromatics to para-xylene utilizing a new catalyst. The new catalyst is a layer MFI zeolite and is represented by the empirical composition in the as synthesized and anhydrous basis expressed by the empirical formula of: $M_m^{n+}R^{p+}AlSi_3O_8$ where M is at least one exchangeable cation selected from the group consisting of alkali and alkaline earth metals and R is at least one organoammonium cation.



IMPROVED YIELDS IN XYLENE ISOMERIZATION USING LAYER MFI ZEOLITES

STATEMENT OF PRIORITY

[0001] This application claims priority to U.S. Application No. 14/636541 which was filed March 3, 2015, the contents of which are hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to a zeolite catalyst for improved performance in hydrocarbon conversion processes. In particular in the process of xylene isomerization for para-xylene production.

BACKGROUND

[0003] Most new aromatics complexes are designed to maximize the yield of benzene and para-xylene. Benzene is a versatile petrochemical building block used in many different products based on its derivation including ethylbenzene, cumene, and cyclohexane. Para-xylene is also an important building block, which is used almost exclusively for the production of polyester fibers, resins, and films formed via terephthalic acid or dimethyl terephthalate intermediates. Accordingly, an aromatics complex may be configured in many different ways depending on the desired products, available feedstocks, and investment capital available. A wide range of options permits flexibility in varying the product slate balance of benzene and para-xylene to meet downstream processing requirements.

[0004] A prior art aromatics complex flow scheme has been disclosed by Meyers in the Handbook of Petroleum Refining Processes, 2d. Edition in 1997 by McGraw-Hill.

[0005] U.S. Pat. No. 3,996,305 to Berger discloses a fractionation scheme primarily directed to trans alkylation of toluene and C₉ alkylaromatics in order to produce benzene and xylene. The trans alkylation process is also combined with an aromatics extraction process. The fractionation scheme includes a single column with two streams entering and with three streams exiting the column for integrated economic benefits.

[0006] U.S. Pat. No. 4,341,914 to Berger discloses a transalkylation process with recycle of C₉ alkylaromatics in order to increase yield of xylenes from the process. The

transalkylation process is also preferably integrated with a paraxylene separation zone and a xylene isomerization zone operated as a continuous loop receiving mixed xylenes from the transalkylation zone feedstock and effluent fractionation zones.

[0007] U.S. Pat. No. 4,642,406 to Schmidt discloses a high severity process for xylene production that employs a transalkylation zone that simultaneously performs as an isomerization zone over a nonmetal catalyst. High quality benzene is produced along with a mixture of xylenes, which allows para-xylene to be separated by absorptive separation from the mixture with the isomer-depleted stream being passed back to the trans alkylolation zone.

[0008] U.S. Pat. No. 5,417,844 to Boitiaux et al. discloses a process for the selective dehydrogenation of olefins in steam cracking petrol in the presence of a nickel catalyst and is characterized in that prior to the use of the catalyst, a sulfur-containing organic compound is incorporated into the catalyst outside of the reactor prior to use.

[0009] The importance of para-xylene production has led to the development of many different processes. However, there are losses associated with these processes.

Improvements to reduce and minimize losses are important for the economics of para-xylene production.

SUMMARY

[0010] A first embodiment of the invention is a process for the production of para-xylene, comprising passing a mixture of hydrocarbons comprising xylenes to an isomerization reactor, operated at isomerization reaction conditions, to form a reaction mixture over an isomerization catalyst, and to generate an effluent stream comprising p-xylene; wherein the isomerization catalyst is characterized by a zeolite having a microporous crystalline structure comprising a framework of AlO_2 and SiO_2 tetrahedral units, and an empirical composition in the as synthesized and anhydrous basis expressed by the empirical formula of $\text{M}_m^{\text{n}+} \text{R}_r^{\text{p}+} \text{AlSi}_y \text{O}_z$ where M is at least one exchangeable cation selected from the group consisting of alkali and alkaline earth metals, "m" is the mole ratio of M to Al and varies from 0 to 3, R is at least one organoammonium cation selected from the group consisting of quaternary ammonium cations, diquaternary ammonium cations, "r" is the mole ratio of R to Al and has a value of 0.1 to 30.0 "n" is the weight average valence of M and has a value of 1 to 2, "p" is the weighted average valence of R and has a value of 1 to 2, "y" is the mole ratio of Si to Al

and varies from greater than 32 to 200 and "z" is the mole ratio of O to Al and has a value determined by the equation $z=(m'n+r'p+3+4y)/2$ and it is characterized in that it has the x-ray diffraction pattern having at least the d spacing and intensities set forth in the following Table A:

Table A

2Θ	d(Å)	I/I_o
7.92-7.99	11.04-11.31	m
8.79-8.88	9.94-11.09	m
20.28-20.56	4.31-4.35	w
23.10-23.18	3.83-3.84	vs
23.86-24.05	3.69-3.72	m
29.90-30.05	2.97-2.98	w
45.02-45.17	2.00-2.01	w

[0011] 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 isomerization reaction conditions include a temperature between 250°C and 350°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 isomerization reaction conditions include a temperature between 280°C and 310°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 isomerization reaction conditions include a pressure sufficient to maintain the reaction mixture in the liquid phase. 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 pressure is at least 1025 kPa. 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 mixture of hydrocarbons further includes ethylbenzene. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph where M in the zeolite is selected from the group consisting of sodium, potassium and mixtures thereof. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph where M in the zeolite is a mixture of an alkali metal and an alkaline earth metal. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up

through the first embodiment in this paragraph where R in the zeolite is selected from the group consisting of tetrabutylammonium hydroxide, tetrabutylphosphonium hydroxide, hexamethonium dihydroxide and mixture thereof. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph where R is a halide or hydroxide compound of an organoammonium cation. 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 catalyst is characterized by a zeolite having a microporous crystalline structure comprising a framework of AlO_2 and SiO_2 tetrahedral units, further including the element E and having the empirical composition in the as synthesized and anhydrous basis expressed by the empirical formula of $M_m^{n+} R_r^{p+} \text{Al}_{1-x} \text{E}_x \text{Si}_y \text{O}_z$ where M is at least one exchangeable cation selected from the group consisting of alkali and alkaline earth metals, "m" is the mole ratio of M to (Al+E) and varies from 0 to 3, R is at least one organoammonium cation selected from the group consisting of quaternary ammonium cations, diquaternary ammonium cations, "r" is the mole ratio of R to (Al+E) and has a value of 0.1 to 30.0 "n" is the weight average valence of M and has a value of 1 to 2, "p" is the weighted average valence of R_1 and has a value of 1 to 2, E is an element selected from the group consisting of gallium, iron, boron, indium and mixtures thereof, "x" is the mole fraction of E and has a value from 0 to 1.0, "y" is the mole ratio of Si to (Al+E) and varies from greater than 32 to 200 and "z" is the mole ratio of O to (Al+E) and has a value determined by the equation $z = (m \cdot n + r \cdot p + 3 + 4y)/2$. 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 passing the effluent stream to a para-xylene separation unit to generate a para-xylene process stream and a second stream comprising meta-xylene and ortho-xylene. 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 separation unit is an adsorption separation unit and generates an extract stream comprising para-xylene and desorbent and a raffinate stream comprising meta-xylene and ortho-xylene. 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 passing the extract stream to a fractionation unit to generate a bottoms stream comprising para-xylene and an overhead stream comprising desorbent. 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 raffinate stream is passed to the isomerization reactor.

[0012] A second embodiment of the invention is a process for the production of para-xylene, comprising passing a mixture of hydrocarbons comprising xylenes to an isomerization reactor, operated at isomerization reaction conditions, to form a reaction mixture over an isomerization catalyst, and to generate an effluent stream comprising para-xylene; wherein the isomerization catalyst is characterized by a catalyst having a 2-D layered MFI structure, to generate a process stream comprising olefins, wherein the catalyst is a zeolite of claim 1 having a microporous crystalline structure comprising a framework of AlO_2 and SiO_2 tetrahedral units, further including the element E and having the empirical composition in the as synthesized and anhydrous basis expressed by the empirical formula of $\text{M}_m^{\text{n}+} \text{R}_r^{\text{p}+} \text{Al}_{1-x} \text{E}_x \text{Si}_y \text{O}_z$ where M is at least one exchangeable cation selected from the group consisting of alkali and alkaline earth metals, "m" is the mole ratio of M to (Al+E) and varies from 0 to 3, R is at least one organoammonium cation selected from the group consisting of quaternary ammonium cations, diquaternary ammonium cations, "r" is the mole ratio of R to (Al+E) and has a value of 0.1 to 30.0 "n" is the weight average valence of M and has a value of 1 to 2, "p" is the weighted average valence of R and has a value of 1 to 2, E is an element selected from the group consisting of gallium, iron, boron, indium and mixtures thereof, "x" is the mole fraction of E and has a value from 0 to 1.0, "y" is the mole ratio of Si to (Al+E) and varies from greater than 32 to 200 and "z" is the mole ratio of O to (Al+E) and has a value determined by the equation $z = (m \cdot n + r \cdot p + 3 + 4y)/2$ and it is characterized in that it has the x-ray diffraction pattern having at least the d spacing and intensities set forth in the following Table A:

Table A

2θ	$d(\text{\AA})$	I/I _o
7.92-7.99	11.04-11.31	m
8.79-8.88	9.94-11.09	m
20.28-20.56	4.31-4.35	w
23.10-23.18	3.83-3.84	vs
23.86-24.05	3.69-3.72	m
29.90-30.05	2.97-2.98	w
45.02-45.17	2.00-2.01	w

[0013] 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 isomerization reaction conditions include a temperature between 250°C and 350°C. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second
5 embodiment in this paragraph wherein the isomerization reaction conditions include a pressure sufficient to maintain the reaction mixture in the liquid phase. 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 pressure is at least 1025 kPa. An embodiment of the invention is one, any or all of prior embodiments in this paragraph up through the second
10 embodiment in this paragraph wherein the mixture of hydrocarbons further includes ethylbenzene.

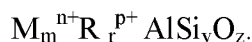
[0014] Other objects, advantages and applications of the present invention will become apparent to those skilled in the art from the following detailed description.

DETAILED DESCRIPTION

[0015] Para-xylene production is a valuable commercial process, wherein the reduction of losses can entail a significant economic advantage. One method of improving para-xylene yields is to increase the conversion from C₈ compounds to para-xylene and to reduce losses during that conversion. The operating of a liquid phase xylene isomerization reactor using a conventional MFI catalyst generates a significant xylene loss per pass. The loss is greater
15 than 1.5%. The invention of a new catalyst allows for a significant reduction in the xylene loss. The new catalyst has a new zeolitic MFI morphology and can achieve comparable para-xylene content with xylene losses of around 0.2% or less.

[0016] The present invention is a process for the production of para-xylene. The process includes passing a mixture of hydrocarbons including xylenes to an isomerization reactor,
25 operated at isomerization reaction conditions to generate an effluent stream having para-xylene, or p-xylene. The reaction conditions include forming a reaction mixture comprising C₈ hydrocarbons and passing the mixture over an isomerization catalyst. The present invention utilizes a new catalyst that reduces the loss of xylenes during the isomerization process. The catalyst is a zeolite catalyst made by using a charge density mismatch method.
30 The isomerization catalyst is a zeolite having a microporous crystalline structure comprising

a framework of AlO_2 and SiO_2 tetrahedral units, and an empirical composition in the as synthesized and anhydrous basis expressed by the empirical formula of:



[0017] The catalyst comprises M, which is at least one exchangeable cation selected from the group consisting of alkali and alkaline earth metals, R, which is at least one organoammonium cation selected from the group consisting of quaternary ammonium cations, diquaternary ammonium cations, E, which is at least one element from gallium, iron, boron and indium. Aluminum and silicon are supplied from alumina and silica. In the formula, "m" is the mole ratio of M to Al and varies from 0 to 3, "r" is the mole ratio of R to Al and has a value of 0.1 to 30.0, "y" is the mole ratio of Si to Al and varies from greater than 32 to 200 and "z" is the mole ratio of O to Al. The value "n" is the weight average valence of M and has a value of 1 to 2, and "p" is the weighted average valence of R and has a value of 1 to 2. The value of "z" is determined by the equation:

$$z = (m \cdot n + r \cdot p + 3 + 4y) / 2.$$

[0018] The catalyst can be further characterized by its unique x-ray diffraction pattern as at least the d spacing and intensities set forth in Table A:

Table A

2 θ	d(Å)	I/I ₀
7.92-7.99	11.04-11.31	m
8.79-8.88	9.94-11.09	m
20.28-20.56	4.31-4.35	w
23.10-23.18	3.83-3.84	vs
23.86-24.05	3.69-3.72	m
29.90-30.05	2.97-2.98	w
45.02-45.17	2.00-2.01	w

[0019] The M in the zeolite can be a mixture of alkali metals and alkaline earth metals, with a preferred M including sodium and potassium. The R cation can be selected from one or more of quaternary ammonium cations, quaternary phosphonium cations, and methonium cations. The R cation can come from an halide compound or a hydroxide compound. Preferred R cations for the zeolite are selected from the reactive materials including one or

more of tetrabutylammonium hydroxide, tetrabutylphosphonium hydroxide and hexamethonium dihydroxide.

[0020] The isomerization reaction conditions include a temperature between 250°C and 350°C, with a preferred reaction temperature between 280°C and 310°C. The reaction conditions include a pressure sufficient to maintain the reaction mixture in the liquid phase. In one embodiment, the pressure in the reactor is at least 1025 kPa, with a preferred reactor pressure in the range of 1750 kPa to 2400 kPa.

[0021] The feedstream preferably comprises C₈ aromatics, having meta-xylene and ortho-xylene. The feedstream can also include ethylbenzene, wherein the isomerization reactor converts the meta-xylene and ortho-xylene to para-xylene, and the ethylbenzene to benzene.

[0022] The effluent stream leaving the isomerization reactor includes para-xylene is passed to a para-xylene separation unit to generate a para-xylene process stream, and a second stream comprising meta-xylene, ortho-xylene and ethylbenzene. The para-xylene separation unit can comprise an adsorption separation unit, wherein the para-xylene process stream is the extract stream and the second stream is the raffinate stream. The extract stream and raffinate streams can include a desorbent. The extract stream is passed to a fractionation unit to generate a bottoms stream comprising para-xylene and an overhead stream comprising desorbent. The process can further include passing the raffinate stream to the isomerization reactor. The raffinate stream can also be passed to a second fractionation column to separate the desorbent from the raffinate stream before passing the raffinate stream to the isomerization reactor.

[0023] In another embodiment, the catalyst is characterized by a zeolite having a microporous crystalline structure comprising a framework of AlO₂ and SiO₂ tetrahedral units, further including the element E and having the empirical composition in the as synthesized and anhydrous basis expressed by the empirical formula of:



[0024] where M is at least one exchangeable cation selected from the group consisting of alkali and alkaline earth metals, "m" is the mole ratio of M to (Al+E) and varies from 0 to 3, R is at least one organoammonium cation selected from the group consisting of quaternary ammonium cations, diquaternary ammonium cations, "r" is the mole ratio of R to (Al+E) and has a value of 0.1 to 30.0 "n" is the weight average valence of M and has a value of 1 to 2,

“p” is the weighted average valence of R and has a value of 1 to 2, E is an element selected from the group consisting of gallium, iron, boron, indium and mixtures thereof, “x” is the mole fraction of E and has a value from 0 to 1.0, “y” is the mole ratio of Si to (Al+E) and varies from greater than 32 to 200 and “z” is the mole ratio of O to (Al+E) and has a value
 5 determined by the equation:

$$z = (m \cdot n + r \cdot p + 3 + 4y)/2.$$

EXAMPLE 1 (Commercial reference example)

[0025] Commercial pentasil zeolite from TOSOH (lot:HSZ-900-940NHA) was formulated into a catalyst containing 70% zeolite and 30% silica. In the catalyst preparation,
 10 the zeolite was mixed with LUDOX AS-40 and Hi-Sil 250 into a muller mixer. Additional water was added to the Muller mixer, while mixing, until dough with a proper texture for extrusion was formed. The dough was extruded to form 1/16” diameter trilobes, which were dried at 100°C overnight and then sized to a length to diameter ratio of 3. The dry extrudates was calcined in a box oven with a flowing air at 560°C for 6 hours to remove the template.
 15 This is referred to as catalyst A.

EXAMPLE 2

[0026] An aluminosilicate reaction solution was prepared by first mixing 13.73 g of aluminum tri-sec-butoxide (95⁺%), 559.89 g tetrabutylphosphonium hydroxide (40 mass-% solution), and 200 g of ice water mixture while stirring vigorously. After thorough
 20 mixing, 574.76 g tetraethyl orthosilicate was added. The reaction mixture was homogenized for an additional hour with a high speed mechanical stirrer. A composite aqueous solution containing 2.70 g of NaOH dissolved in 48.92 g distilled water, was added, drop-wise, to the aluminosilicate solution. After the addition was completed, the resulting reaction mixture was homogenized for 1 hour, transferred to a 2000 ml Parr stainless steel autoclave which was
 25 heated to 115°C and maintained at that temperature for 120 hrs. The solid product was recovered by centrifugation, washed with de-ionized water, and dried at 80°C.

[0027] The product was identified as a pentasil zeolite by powder x-ray diffraction. Representative diffraction lines observed for the product are shown in Table 1. A portion of the material was calcined by ramping to 560°C for 5 hours followed by a 8 hour dwell in air.
 30 The BET surface area was 526 m²/g, the micropore area was 220 m²/g, the mesopore area

was 306 m²/g, the micropore volume was 0.115 cc/g, and mesopore volume was 0.99 cc/g. Scanning Electron Microscopy (SEM) revealed clusters of nano spheres of less than 20 nm. Chemical analysis was as follows: 1.22% Al, 42.8% Si, and 0.70% Na, Na/Al=0.67, Si/Al₂=49.8.

5

TABLE 1

2θ	d(Å)	I/I ₀ %
7.99	11.04	m
8.88	9.94	m
20.50	4.32	w
23.16	3.83	vs
24.05	3.69	m
30.05	2.97	w
45.02	2.01	w

EXAMPLE 3 (PENTASIL LAYERED EXTRUDATES)

[0028] The pentasil zeolite of example 3 was formulated into a catalyst containing 70% zeolite and 30% silica. In the catalyst preparation, the zeolite was mixed with LUDOX AS-40 and Hi-Sil 250 into a muller mixer. Additional water was added to the Muller mixer, while mixing, until dough with a proper texture for extrusion was formed. The dough was extruded to form 1/16" diameter trilobes, which were dried at 100°C overnight and then sized to a length to diameter ratio of 3. The dry extrudates was calcined in a box oven with a flowing air at 560°C for 6 hours to remove the template. The calcined support was then exchanged using a 10 wt-% NH₄NO₃ solution at 75°C for one hour. This was followed by water wash using 20 cc of water per cc of extrudates. The NH₄NO₃ exchange and water wash was repeated three more times. The extrudates was then dried at 120°C for 4 hours and then activated at 550°C. This is labeled catalyst B.

EXAMPLE 4

[0029] An aluminosilicate reaction solution was prepared by first mixing 13.87 g of aluminum tri-sec-butoxide (95⁺%), 386.39 g tetrabutylammonium hydroxide (55 mass-% solution), and 300 g of ice water mixture while stirring vigorously. After thorough mixing, 580.35 g tetraethyl orthosilicate was added. The reaction mixture was homogenized for an additional hour with a high speed mechanical stirrer. A composite aqueous solution

containing 2.73 g of NaOH dissolved in 116.67 g distilled water was added, drop-wise, to the aluminosilicate solution. After the addition was completed, the resulting reaction mixture was homogenized for 1 hour, transferred to a 2000 ml Parr stainless steel autoclave which was heated to 115°C and maintained at that temperature for 57 hrs. The solid product was recovered by centrifugation, washed with de-ionized water, and dried at 80°C.

[0030] The product was identified as a pentasil zeolite by powder x-ray diffraction. Representative diffraction lines observed for the product are shown in Table 2. The product composition was determined by elemental analysis to consist of the following mole ratios: Si/Al = 24.9, Na/Al = 0.92. A portion of the material was calcined by ramping to 560°C for 5 hours followed by a 8 hour dwell in air. The BET surface area was 517 m²/g, the micropore area was 258 m²/g, the mesopore area was 259 m²/g, the micropore volume was 0.135 cc/g, and mesopore volume was 0.94 cc/g. Scanning Electron Microscopy (SEM) revealed clusters of nano spheres of less than 20 nm. Chemical analysis was as follows: 1.73% Al, 44.9% Si, and 1.37% Na, Na/Al=0.93, Si/Al₂=49.8.

TABLE 2

2θ	d(Å)	I/I ₀ %
7.94	11.12	m
8.79	10.04	m
20.38	4.35	w
23.16	3.83	vs
23.86	3.72	m
29.96	2.98	w
45.07	2.00	w

EXAMPLE 5

[0031] The pentasil zeolite of example 3 was formulated into a catalyst containing 70% zeolite and 30% silica. In the catalyst preparation, the zeolite was mixed with LUDOX AS-40 and Hi-Sil 250 into a Muller mixer. Additional water was added to the Muller mixer, while mixing, until dough with a proper texture for extrusion was formed. The dough was extruded to form 1/16" diameter trilobes, which were dried at 100°C overnight and then sized to a length to diameter ratio of 3. The dry extrudates was calcined in a box oven with a flowing air at 560°C for 6 hours to remove the template. The calcined support was then exchanged using a 10 wt-% NH₄NO₃ solution at 75°C for one hour. This was followed by water wash

using 20 cc of water per cc of extrudates. The NH_4NO_3 exchange and water wash was repeated three more times. The extrudates was then dried at 120°C for 4 hours and then activated at 550°C .

EXAMPLE 6

- 5 **[0032]** Catalyst A was evaluated for xylene isomerization and ethyl-benzene retention using a pilot plant flow reactor processing a non-equilibrium C_8 aromatic feed having the following composition in wt-%:

C_8 non-aromatics	0.5
ethylbenzene	4.5
para-xylene	0.9
meta-xylene	64.6
ortho-xylene	29.5

- 10 **[0033]** Pilot-plant test conditions and results are as follows. The above feed contacted the Catalyst at a pressure of 3.5 MPa in the liquid phase at a weight hourly space velocity of 10 under a range of temperatures. The resulting performance measures are shown below:

	Catalyst A	Catalyst B	Catalyst C
WHSV, hr ⁻¹	10	10	10
Temperature to reach 23 PX/X	348	314	320
Xylene Loss	1.31	0.20	0.30
A11+ selectivity	0.24	0.11	0.06

- 15 **[0034]** Note that the “Xylene Loss” is in mol-% defined as “ $(1 - (\text{para, meta, ortho xylene in product}) / (\text{-(para, meta, ortho xylene in feed)}) * 100$ ”, which represents material that has to be circulated to another unit in an aromatics complex. Such circulation is expensive and a low amount of C_8 ring loss is preferred. A11+ represents material that is heavier than 145 molecular weight. This material represents unrecoverable losses. Ethylbenzene conversion,
20 2 to 4.5% was low in all cases.

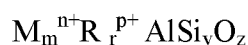
[0035] While the invention has been described with what are presently considered the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but it is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.

CLAIMS

1. A process for the production of para-xylene, comprising:

passing a mixture of hydrocarbons comprising xylenes to an isomerization reactor,
operated at isomerization reaction conditions, to form a reaction mixture over an
isomerization catalyst, and to generate an effluent stream comprising p-xylene;

wherein the isomerization catalyst is characterized by a zeolite having a microporous
crystalline structure comprising a framework of AlO_2 and SiO_2 tetrahedral units, and an
empirical composition in the as synthesized and anhydrous basis expressed by the empirical
formula of:



where M is at least one exchangeable cation selected from the group consisting of alkali and
alkaline earth metals, "m" is the mole ratio of M to Al and varies from 0 to 3, R is at least one
organoammonium cation selected from the group consisting of quaternary ammonium
cations, diquaternary ammonium cations, "r" is the mole ratio of R to Al and has a value of
0.1 to 30.0 "n" is the weight average valence of M and has a value of 1 to 2, "p" is the
weighted average valence of R and has a value of 1 to 2, "y" is the mole ratio of Si to Al and
varies from greater than 32 to 200 and "z" is the mole ratio of O to Al and has a value
determined by the equation:

$$z = (m \cdot n + r \cdot p + 3 + 4 \cdot y) / 2$$

and it is characterized in that it has the x-ray diffraction pattern having at least the d spacing
and intensities set forth in the following Table A:

Table A

2θ	$d(\text{\AA})$	I/I ₀
7.92-7.99	11.04-11.31	m
8.79-8.88	9.94-11.09	m
20.28-20.56	4.31-4.35	w
23.10-23.18	3.83-3.84	vs
23.86-24.05	3.69-3.72	m
29.90-30.05	2.97-2.98	w
45.02-45.17	2.00-2.01	w

2. The process of claim 1 wherein the isomerization reaction conditions include a temperature between 250°C and 350°C.

3. The process of claim 2 wherein the isomerization reaction conditions include a temperature between 280°C and 310°C.

4. The process of claim 1 wherein the pressure is at least 1025 kPa.

5. The process of claim 1 wherein the mixture of hydrocarbons further includes ethylbenzene.

6. The process of claim 1 where M in the zeolite is selected from the group consisting of sodium, potassium and mixtures thereof.

7. The process of claim 1 where M in the zeolite is a mixture of an alkali metal and an alkaline earth metal.

8. The process of claim 1 where R in the zeolite is selected from the group consisting of tetrabutylammonium hydroxide, tetrabutylphosphonium hydroxide, hexamethonium dihydroxide and mixture thereof.

9. The process of claim 1 where R is a halide or hydroxide compound of an organoammonium cation.

10. The process of claim 1 further comprising:
passing the effluent stream to a para-xylene separation unit to generate a para-xylene process stream and a second stream comprising meta-xylene and ortho-xylene.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2016/020010

A. CLASSIFICATION OF SUBJECT MATTER

C07C 15/08 (2006.01)
C07C 5/22 (2006.01)
C01B 39/04 (2006.01)
B01J 29/06 (2006.01)

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 15/08, 5/22, C01B 39/04, B01J 29/06

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)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/123144 A1 (UOP LLC et al.) 06.10.2011, claims, abstract, par. [0034, [0039]	1-10
A	US 5417844 A (INSTITUT FRANCAIS DU PETROLE) 23.05.1995	1-10

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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 document 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

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