PRODUCTION OF NAPHTHALENE AND BENZENE

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This invention relates to a process for the dealkylation of alkyl-substituted aromatic hydrocarbons to produce naphthalene and benzene. Petroleum fractions which boil within the range of 400-600°F generally contain significant amounts of monocyclic and dicyclic aromatic hydrocarbons such as alkyl benzene and alkyl naphthalene. Recycle fractions, which are formed in the cracking of petroleum stocks and which include this boiling range, often contain major proportions of aromatic hydrocarbons that are mainly alkyl naphthalenes and in smaller quantity, the alkyl benzenes. Such fractions typically may have aromatic contents varying within the range of 25-97 percent but usually contain between 50 percent and 95 percent aromatics depending upon the particular operation in which the petroleum fractions are produced. These hydrocarbon charge stocks are obtained in both catalytic and thermal cracking processes and in operations in which combinations of catalytic and thermal cracking steps are utilized. Stocks having high alkyl-substituted aromatic hydrocarbon contents can also be obtained by extracting straight-run petrolem fractions of appropriate boiling ranges, such as kerosene, or catalytic fractions such as catalytic gas oil, with solvents such as furfural or sulfur dioxide, or by selective adsorption with silica gel. These aromatic concentrates may contain up to 100 percent aromatic hydrocarbons.

The present invention is directed to the preparation of naphthalene and benzene from aromatic charge stocks which comprise a mixture of alkyl-substituted aromatic feed stocks and which can be derived from such sources as referred to above. The charge stock may boil within the range of 200-600°F but more preferably in the range of 400-515°F.

It has been proposed heretofore to prepare naphthalene by subjecting aromatic hydrocarbon stocks containing alkyl naphthalenes to high temperature dealkylation in the presence of hydrogen. In addition, there have been processes which dealkylate alkyl benzenes. However, each of these processes have peculiarities which tend to make them special processes. For example, conventional thermal hydrocracking processes operate in a single stage at a high temperature in excess of 1,300°F. However, this procedure has not proved too satisfactory for commercial practice for the reason that a highly exothermic reaction occurs which causes the temperature to rise sharply above the level that can be tolerated safely in plant operation. Concomitantly, recovery procedures described in the prior art usually involve complicated means for removing the heat of reaction, e.g., moving beds of inert solids as described in British Patent No. 712,441 or catalytic processes which operate either at lower temperatures or in such a way that the heat of reaction is dissipated as described in United States Patent No. 2,653,176.

Furthermore, it is well known in the art that the dealkylation of alkyl benzenes has been difficult to achieve.

In fact, practically all of the prior art describes various catalytic processes which are said to accomplish the desired dealkylation. A typical example of the prior art is contained in British Patent No. 657,194 which proposes to demethylate methyl benzenes in the presence of a catalyst consisting of activated alumina or of activated alumina and hydrogen chloride.

The present invention provides basically a thermal process for the simultaneous production of naphthalene and benzene from charge stocks as specified above, wherein excessive temperature rise due to the exothermic nature of the reaction is avoided, and the thermal dealkylation of alkyl benzenes to benzene proceeds easily.

The invention may be more fully understood by reference to the accompanying drawings, in which:

FIGURE 1 is a schematic flow diagram illustrating one embodiment of the invention, and

FIGURE 2 is a schematic flow diagram illustrating the preferred manner of practicing the invention.

According to the invention the charge material is first subjected to hydrocracking under conditions including a temperature not exceeding 1,100°F at which the non-aromatic components are converted to low boiling compounds at a slow enough rate to prevent excessive temperature rise. Under these conditions substantial conversion of the alkyl naphthalenes and alkyl benzenes into naphthalene and benzene, respectively, does not occur. Reaction product from this first step is admixed with two recycle streams hereinafter specified and is then subjected in a second step to hydrocracking at a higher temperature within the range of 1,100°F to 1,800°F whereby dealkylation of the alkyl naphthalenes and alkyl benzenes occurs. Due to the fact that the non-aromatic components have already been largely removed in the first cracking stage, the temperature rise in the second hydrocracking reaction does not rise excessively, and safe operating conditions are easily maintained. The final reaction product is fractionated to obtain naphthalene in high purity, a gasoline stream enriched in benzene and alkyl benzenes, and a bottom fraction rich in unreacted alkyl naphthalenes. The unreacted alkyl naphthalenes are recycled to the dealkylator in admixture with the feed stock thus increasing the ultimate yield of naphthalene. The gasoline stream is then fractionated to recover a benzene fraction and an alkyl benzene fraction. At least a portion of the alkyl benzenes are also recycled to the dealkylator in admixture with the feed thus substantially increasing the ultimate yield of benzene from the process.

In a further embodiment at least a portion of the benzene fraction is recycled in a manner hereinafter specified in order to substantially increase the yield of naphthalene and benzene from practice of the invention.

In one embodiment of the invention both the first and second hydrocracking steps are carried out thermally in the absence of any catalyst. In this embodiment the charge stock is subjected first to thermal cracking in the presence of sufficient hydrogen to minimize coke formation, e.g., 500-5,000 s.c.f. per barrel of feed, and under conditions which will cause the non-aromatic hydrocarbons to crack at a rate that avoids an inordinate rise in temperature but which does not effect substantial conversion of the alkyl naphthalenes into naphthalene and the alkyl benzenes into benzene. These conditions include a temperature within the range of 1,000-1,100°F, a pres-
sure of 150-1,000 p.s.i.g. and more preferably 200-500 p.s.i.g., a hydrogen-to-hydrocarbon mole ratio within the range of 3:1 and 25:1 and preferably 5:1 to 15:1, and a residence time of 2-300 seconds with a preferred residence time of 10-60 seconds. Means may be provided in this first cracking step for removing heat from the reaction zone to ensure that the reaction temperature will not rise above 1,100°F. Reaction product from the first cracking step is then subjected to more severe thermal hydrocracking conditions in the second step to convert the alkyl naphthalenes and the alkyl benzene into napthalene and benzene, respectively. The conditions for the second step include a temperature within the range of 1,100°F to 1,800°F, a pressure between 50 and 2,500 p.s.i.g., residence time of 2-300 seconds with a preferred residence time of 10-60 seconds, and in the presence of an excess of one molecule of hydrogen per atom of alkyl carbon in a substituted aromatic hydrocarbon, e.g., a hydrogen-to-hydrocarbon mole ratio within the range of 3:1 to 25:1 and preferably 10:1 to 20:1. Naphthalene in high concentration is readily obtainable from the final reaction product by fractional distillation. Benzene is recovered in high yield by fractionating the gasoline fraction obtained from the dealkylation product. The unreacted alkyl naphthalenes and alkyl benzenes are recycled to the dealkylator to insure maximum yield of naphthalene and benzene from the process.

In a desirable embodiment of the invention, the first hydrocracking reaction is carried out in the presence of a desulfurizing catalyst while the second step involves thermal hydrocracking under the conditions described above for the preceding embodiment. The use of a desulfurizing catalyst in the first hydrocracking step facilitates cracking of the non-aromatic hydrocarbons and permits the use of a lower reaction temperature, as well as desulfurization by converting sulfur compounds in the charge to hydrogen sulfide. Any of the known desulfinatization catalysts, such as, for example, cobalt molybdate on alumina or molybdenum disulfide on alumina, can be used in practicing this embodiment of the invention. The conditions for conducting the catalytic hydrocracking and demulsifying step include a temperature within the range of 800-1,100°F, a pressure of 150-1,000 p.s.i.g., with a range of 200-500 p.s.i.g. preferred, a hydrogen-to-hydrocarbon mole ratio of 5:1 to 25:1 and preferably 5:1 to 15:1, and a liquid hourly space velocity of 0.2-10 (volumes of charge per hour per bulk volume of catalyst).

As stated above, conditions for the succeeding thermal hydrocracking step are the same as previously described. In this preferred embodiment the alkyl benzene containing stream is recycled to the thermal hydrocracking zone for effective dealkylation.

A still further manner of practicing the invention involves either thermally or catalytically cracking the charge, as described above, in a first step and then catalytically dealkylating the alkyl naphthalenes and alkyl benzenes in the presence of a desulfurization catalyst. In addition to the catalyst described hereinafore for the desulfurization step, it is preferred that the catalytic dealkylation step be conducted in the presence of a chromia or molybdena catalyst. Further, the chromia or molybdena is usually supported on a suitable carrier such as oxides of aluminum, zirconium, zinc, magnesium, titanium, silicon, and thorium. The choice of the catalyst in the dealkylation step facilitates the dealkylation reaction, particularly the dealkylation of the alkyl benzenes, and usually permits it to be carried out at a lower temperature than that required for thermal dealkylation. The conditions for the catalytic dealkylation step include a temperature within the range of 900-1,200°F, preferably between 1,050°F and 1,150°F, a pressure of 150-1,000 p.s.i.g. with a range of 200-500 p.s.i.g. preferred, a hydrogen-to-hydrocarbon ratio of 5:1 to 25:1, and a liquid hourly space velocity of 0.2 to 5.0.

In a preferred embodiment of the invention, the charge stock is first subjected to a catalytic hydrocracking reaction to remove non-aromatic hydrocarbons and sulfur compounds. The second step involves the catalytic cracking, in the substantial absence of hydrogen, of the conditioned charge stock in the presence of two recycle streams hereinafter described. In this second step the alkyl naphthalenes are substantially dealkylated via an alkyl transfer reaction. The product from the second step is admixed with hydrogen and another recycle stream hereinafter defined and subjected to thermal hydrodealkylation. Naphthalene and benzene are obtained from the final reaction product by fractional distillation. Benzene is recovered in high yield by fractionating the gasoline fraction obtained from the dealkylation product. The unreacted monoalkyl naphthalenes are recycled to the second or catalytic cracking zone. In addition, at least a portion of the benzene naphthalene or benzene is sent to the second or catalytic cracking zone whereby alkyl groups are transferred from the naphthalene nucleus to the benzene nucleus via the above-mentioned alkyl transfer reaction. The unreacted alkyl benzene contained in the gasoline fraction are recycled to the thermal hydrodealkylation zone wherein the alkyl side chains are reacted from the benzene rings and from the remaining alkylated naphthalene rings. It has been found that by operating in the above-described manner, significant increases in the yield of benzene and naphthalene can be realized.

As described hereinafore, the conditions for the catalytic hydrocracking step are the same as previously described. Further, conditions for the final thermal hydrodealkylation step are the same as previously described. In the preferred embodiment, the conditions for the second or catalytic cracking step include a temperature between 100°F and 1,000°F, a pressure between atmospheric and 1,000 p.s.i.g. with a range of 50-150 p.s.i.g. preferred, and the presence of a catalyst selected from the broad group of catalysts known as acid-acting materials. Suitable catalysts include the activated clays, e.g., fuller's earth, pumice, and the like; cracking catalysts such as the common silica-alumina catalysts; and so-called metal halides such as aluminum chloride and aluminum bromide. The reaction may take place in either liquid or gaseous phase with the reaction time varying from about 2 seconds to 5 hours, with the preferred residence time being between 2 minutes and 30 minutes.

In practicing either of the foregoing embodiments of the invention, it is preferable to subject the first reaction product to distillation to obtain a fraction boiling mainly in the range of 400-525°F. For use as charge to second step. This distillation removes material formed in the first hydrocracking reaction which boils below 400°F and which is a suitable component for gasoline. It also removes material which will not contribute materially to the formation of either naphthalene or benzene in succeeding process steps. Further, it removes a minor amount of polymeric material that boils above about 525°F and which would tend to form coke if allowed to remain in the charge to the second step.

In the reaction stages of each of the foregoing embodiments, coking occurs after a time to such extent that coke removal from the reaction zone is required. This can be accomplished manually, by passing an oxygen-containing gas through the reaction zone to burn off the coke. In the embodiments in which a desulfurizing catalyst is used, burning of coke from the catalyst restores its catalytic activity.

As used herein, the term "hydrocracking" is primarily defined as the cumulative result of cleaving, i.e., cracking, carbon-carbon bonds and of adding hydrogen to the cleaved bonds.

The present invention provides an improved process for producing naphthalene in which a substantially increased
over-all rate of dealkylation of alkyl naphthalenes is attained. Further, the present invention provides a novel process for simultaneously producing benzene from alkyl benzene in high concentration.

The invention is described more specifically with reference to the accompanying drawings of which FIGURE 1 is a schematic flow sheet illustrating a satisfactory manner for producing naphthalene and benzene from a hydrocarbon feed containing alkyl naphthalenes and aromatic hydrocarbons, and FIGURE 2 is a schematic flow sheet illustrating a preferred processing operation.

With reference to FIGURE 1, the process as illustrated involves a preliminary catalytic hydrocracking-desulfurization step adapted to condition the alkyl-substituted aromatic charge material prior to the thermal dealkylation step for producing naphthalene and benzene. The charge, which enters the system through line 10, is a gas oil fraction boiling in the range of 400--550° F. and containing alkyl naphthalenes and alkyl benzenes, and preferably is a catalytic gas oil aromatic extract boiling in the range of the 450--515° F. and containing a major proportion of disethyl aromatics with a minor proportion of monoethyl aromatics having only one aromatic ring and only a small amount, e.g., 3--8 percent, of saturated hydrocarbons. For example, a preferred charge may contain 60 percent disethyl aromatics, 25 percent monoeethyl aromatics, and 5 percent saturates.

The heated charge together with hydrogen from line 11 passes to a catalytic hydrocracker-desulfurizer 12 which preferably contains cobalt molybdate on alumina as the catalyst. The desulfurizer is operated at a temperature of about 970° F., a pressure of about 275 p.s.i.g., a hydrogen-to-hydrocarbon mole ratio of about 10:1, and a liquid hourly space velocity of about 2. The hydrogen consumption under these conditions should be between 65--500 s.c.f. per barrel of liquid feed per percent sulfur in the feed and preferably between 200 and 400 s.c.f. per barrel per percent. This conditioning step effects cracking of most of the saturates and converts most of the sulfur in the hydrocarbon stock to hydrogen sulfide.

From desulfurizer 12 the reaction product preferably is sent through line 13 to fractionator 14 from which normally gaseous components including hydrogen sulfide are removed overhead through line 15 and a C_5--400° F. gas-oil fraction is obtained from line 16. The 450--400° F. fraction contains the alkyl naphthalenes and the remaining alkyl benzenes is removed via line 17 and sent to thermal dealkylator 19. Alternatively, all of the reaction product from desulfurizer 12 can be sent to the dealkylator (not shown).

The 400--450° F. fraction from line 17 is admixed with a recycle fraction from line 20, as hereinafter specified; and the mixture passes into dealkylator 19 together with hydrogen introduced via line 18. In this embodiment the dealkylation is effected thermally without a catalyst.

Typical conditions for this operation include a pressure of about 400 p.s.i.g., a hydrogen-to-hydrocarbon mole ratio of about 10:1, a residence time of about 10 seconds, and a temperature above 1,000° F., preferably about 1,200° F., sufficient to effect dealkylation of the alkyl-substituted aromatic hydrocarbons. In this reaction only a partial dealkylation is effected. Hence the reaction product which leaves through line 21 contains, in addition to naphthalene and benzene, unreacted naphthalenes, partially dealkylated naphthalenes, unreacted benzenes, and partially dealkylated benzenes.

The reaction product from line 21 passes to fractionator 22 from which gases and a C_5--400° F. aromatic gasoline cut are removed, respectively, from lines 23 and 24. The naphthalene product is taken from line 25 as material boiling in the 200--450° F. range. Typically this fraction is composed predominantly of naphthalene and has a freezing point of 78.6° C. and a sulfur content of the order of 0.06 percent.

The 450--400° F. material withdrawn from fractionator 22 via line 26 is composed predominantly of monomethyl and dimethyl naphthalenes. Desirably this stream is passed through line 26 to fractionator 27 from which the monomethyl naphthalenes are obtained overhead through line 28, and the higher boiling material is removed as bottoms via line 29. In order to increase the yield of naphthalene from the process, the unconverted monoalkyl naphthalenes can be continuously recycled to the dealkylator (not shown).

The aromatic gasoline cut removed from fractionator 22 via line 24 is passed into superfractionator 30 from which benzene is recovered through overhead line 31. The bottoms fraction containing mainly alkyl benzenes is removed via line 32 and at least a portion of the stream is continuously recycled to dealkylator 19 via line 28 in admixture with the conditioned charge and hydrogen. In the dealkylator the alkyl benzenes are converted to benzene. Highly aromatic gasoline is recovered through line 33. By removing benzene from the gasoline portion of the dealkylation product and recycling at least a portion of the alkyl benzenes, the yield of benzene from the process is significantly increased.

Thus, in essence the present invention relates in one embodiment to a process for the production of naphthalene and benzene which comprises the steps of (1) subjecting a feed stock containing alkyl-substituted aromatic hydrocarbons boiling within the range 200° F. to 600° F. in a reaction zone free of active catalyst for at least one second to hydrocracking conditions including a temperature within the range 1,100° F. to 1,800° F., a pressure between 30 and 2,500 p.s.i.g., in the presence of an excess of one molecule of hydrogen per atom of alkyl carbon in a substituted aromatic hydrocarbon to produce a product enriched in naphthalene and benzene; (2) separating the product into at least a naphthalene-rich fraction and a fraction containing benzene and alkyl benzene; (3) recovering naphthalene; (4) recovering benzene; and (5) recycling at least a portion of the fraction containing alkyl benzene to the reaction zone.

With reference to FIGURE 2 which illustrates a specific embodiment of the invention, the preferred process involves the same conditioning step as previously illustrated. Preferably, line 40--450° F. fraction from line 17 is admixed with two recycle fractions from lines 37 and 29, respectively, as hereinafter specified; and the mixture passes in the absence of hydrogen through line 18 into catalytic cracker 19. In this reaction, dealkylation of the alkyl naphthalenes is effected catalytically via hydrogen transfer of hydrogen from naphthalene to benzene. Typically the catalyst is boron trifluoride in admixture with hydrogen fluoride supported on a suitable siliceous adsorbent. The reaction proceeds easily at 250° F. and 650 p.s.i.g. Substantial amounts of alkyl naphthalenes are dealkylated in this step.

The catalytically-cracked product is removed from cracker 19, admixed with a recycle fraction from line 34 and passed through line 38 with hydrogen introduced through line 28 into thermal dealkylator 21. In this step, the predominating reaction is the dealkylation of the alkyl benzenes since the alkyl naphthalenes have been substantially dealkylated in the previous step. The operating conditions are a temperature of 1,200° F., pressure of 410 p.s.i.g., hydrogen-to-hydrocarbon mole ratio of 10:1, and a residence time of 20 seconds. The hydrogen consumed is about 2,000 s.c.f. per barrel of fresh feed. The dealkylation products are passed through line 22 into fractionator 23 where gas, including hydrogen sulfide, is removed via line 24, a C_5--400° F. gasoline cut is removed via line 25, a naphthalene-rich stream from line 26, and a 450--450° F. fraction is removed via line 27. The naphthalene from line 26 is obtained in a better than 90 percent yield and has a 79--4° C. freezing point.

The C_5--400° F. gasoline fraction is obtained in about
18 percent yield and has the following composition: (by volume).

<table>
<thead>
<tr>
<th>Percent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>8.3</td>
</tr>
<tr>
<td>Toluene</td>
<td>20.3</td>
</tr>
<tr>
<td>Xylene</td>
<td>24.0</td>
</tr>
<tr>
<td>C₉ and C₁₀ alkyl aromatics</td>
<td>13.1</td>
</tr>
<tr>
<td>Indanes</td>
<td>14.1</td>
</tr>
</tbody>
</table>

This fraction is passed via line 25 into fractionator 31 where the benzene is recovered overhead via line 35 and a gasoline cut containing alkyl benzenes is removed via line 32. As pointed out hereinafter, at least a portion of the alkyl benzene cut is recycled to the thermal dealkylator via line 34 in order to maximize the yield of benzene. And, at least a portion of the benzene product is recycled via line 37 to the catalytic cracker to function as an alkyl acceptor during the dealkylation of the alkyl naphthalenes.

The 450-4°F fraction from fractionator 23 is passed through line 27 into fractionator 30 where the monoalkyl naphthalenes are removed overhead via line 29 and are recycled in admixture with fresh charge and recycle benzene into catalytic cracker 19. The 500-4°F fraction is removed as a bottoms product via line 28.

Therefore, the preferred embodiment of this invention relates to a process for the production of naphthalene and benzene which comprises the steps of (1) subjecting as a feed stock containing alkyl-substituted aromatic hydrocarbons boiling within the range 200–600°F to catalytic hydrocracking in the presence of a desulfurization catalyst and added hydrogen under reaction conditions including a temperature between 800°F and 1100°F, pressure of 150 to 1500 p.s.i.g., hydrogen to hydrocarbon mole ratio of 5:1 to 25:1, and a liquid hourly space velocity of 0.2 to 10, to convert non-aromatic hydrocarbons to lower-boiling compounds and to convert sulfur mainly to hydrogen sulfide without substantial conversion of alkyl naphthalenes to naphthalene and without substantial conversion of alkyl benzenes to benzene; (2) admixing the conditioned reaction product with hereinafter specified first and second recycle streams; (3) subjecting this admixed reaction product to catalytic cracking in the presence of benzene under conditions whereby alkyl naphthalenes are dealkylated by transferring alkyl groups to benzene; (3) subjecting the cracked product to thermal hydrocracking under conditions sufficient to dealkylate alkyl benzene; (4) separating the dealkylated product into at least a naphthalene-rich fraction, a portion containing benzene and alkyl benzene, and a fraction rich in alkyl naphthalenes; (5) recovering naphthalene; (6) separating the benzene and alkyl benzene; (7) recyling at least a portion of alkyl benzene to the thermal dealkylating step; (8) recycling at least a portion of the naphthalene fraction to the catalytic cracking step; (9) recyling at least a portion of the benzene fraction as said first recycle stream in the catalytic cracking step; (10) recyling an alkyl naphthalene fraction comprising monoalkyl naphthalenes as said second recycle stream in the catalytic cracking step; (11) recyling at least a portion of the alkyl benzene fraction as said third recycle stream in the hydrocracking step; (12) recovering benzene in high concentration; (3) for the production of naphthalene and benzene which comprises the steps of (1) subjecting as a feed stock containing alkyl-substituted aromatic hydrocarbons boiling within the range 200–600°F to catalytic hydrocracking in the presence of a desulfurization catalyst at a temperature within the range of 800–1100°F, pressure of 150 to 1500 p.s.i.g., hydrogen to hydrocarbon mole ratio of 5:1 to 25:1, and a liquid hourly space velocity of 0.2 to 10, to convert non-aromatic hydrocarbons to lower-boiling compounds and to convert sulfur mainly to hydrogen sulfide without substantial conversion of alkyl naphthalenes to naphthalene and without substantial conversion of alkyl benzenes to benzene; (2) admixing the conditioned reaction product with hereinafter specified first and second recycle streams; (3) subjecting said conditioned reaction product to catalytic cracking in the presence of benzene under conditions whereby alkyl naphthalenes are dealkylated by transferring alkyl groups to benzene; (3) subjecting the cracked product to thermal hydrocracking under conditions sufficient to dealkylate alkyl benzene; (4) separating the dealkylated product into at least a naphthalene-rich fraction, a portion containing benzene and alkyl benzene, and a fraction rich in alkyl naphthalenes; (5) recovering naphthalene; (6) separating the benzene and alkyl benzene; (7) recyling at least a portion of alkyl benzene to the thermal dealkylating step; (8) recycling at least a portion of the naphthalene fraction to the catalytic cracking step; (9) recyling at least a portion of the benzene fraction as said first recycle stream in the catalytic cracking step; (10) recyling an alkyl naphthalene fraction comprising monoalkyl naphthalenes as said second recycle stream in the catalytic cracking step; (11) recyling at least a portion of the alkyl benzene fraction as said third recycle stream in the hydrocracking step; (12) recovering benzene in high concentration; (3) for the production of naphthalene and benzene which comprises the steps of (1) subjecting as a feed stock containing alkyl-substituted aromatic hydrocarbons boiling within the range 200–600°F to catalytic hydrocracking in the presence of a desulfurization catalyst at a temperature within the range of 800–1100°F, pressure of 150 to 1500 p.s.i.g., hydrogen to hydrocarbon mole ratio of 5:1 to 25:1, and a liquid hourly space velocity of 0.2 to 10, to convert non-aromatic hydrocarbons to lower-boiling compounds and to convert sulfur mainly to hydrogen sulfide without substantial conversion of alkyl naphthalenes to naphthalene and without substantial conversion of alkyl benzenes to benzene; (2) admixing the conditioned reaction product with hereinafter specified first and second recycle streams; (3) subjecting said conditioned reaction product to catalytic cracking in the presence of benzene under conditions whereby alkyl naphthalenes are dealkylated by transferring alkyl groups to benzene; (3) subjecting the cracked product to thermal hydrocracking under conditions sufficient to dealkylate alkyl benzene; (4) separating the dealkylated product into at least a naphthalene-rich fraction, a portion containing benzene and alkyl benzene, and a fraction rich in alkyl naphthalenes; (5) recovering naphthalene; (6) separating the benzene and alkyl benzene; (7) recyling at least a portion of alkyl benzene to the thermal dealkylating step; (8) recycling at least a portion of the naphthalene fraction to the catalytic cracking step; (9) recyling at least a portion of the benzene fraction as said first recycle stream in the catalytic cracking step; (10) recyling an alkyl naphthalene fraction comprising monoalkyl naphthalenes as said second recycle stream in the catalytic cracking step; (11) recyling at least a portion of the alkyl benzene fraction as said third recycle stream in the hydrocracking step; (12) recovering benzene in high concentration.
cracking in the presence of benzene under conditions whereby alkyl naphthalenes are dealkylated by transferring alkyl groups to benzene; (3) subjecting the cracked product to thermal hydrocracking under conditions sufficient to dealkylate alkyl benzene; (4) separating the dealkylated product into at least a naphthalene-rich fraction, a fraction containing benzene and alkyl benzene, and a fraction rich in alkyl naphthalenes; (5) recovering naphthalene; (6) separating the benzene and alkyl benzene; (7) recycling at least a portion of benzene as said benzene in the catalytic cracking step; (8) recycling at least a portion of the alkyl benzene to the thermal dealkylating step; and (9) recovering benzene.

4. Process according to claim 3 wherein said fraction rich in alkyl naphthalenes is recycled to the catalytic cracking step.

References Cited in the file of this patent

UNITED STATES PATENTS

2,355,366  Conn __________________ Aug. 8, 1944
2,389,713  Atwell ________________ Nov. 27, 1945
2,734,929  Doumani ________________ Feb. 14, 1956
2,768,219  Hoffmann et al. ________ Oct. 23, 1956
2,795,633  Coonradt et al. ________ June 11, 1957