

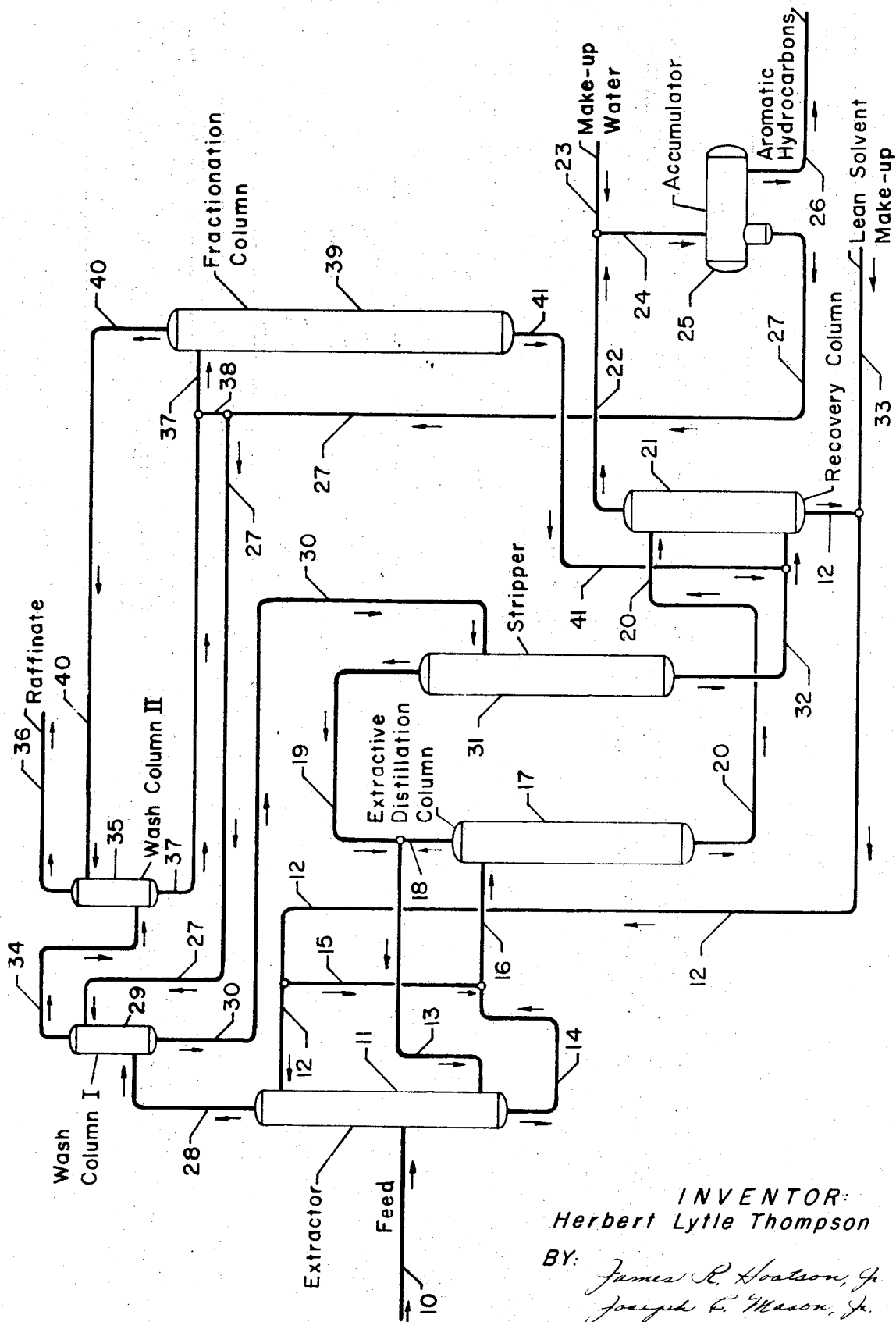
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PROCESS FOR THE EXTRACTION AND RECOVERY OF AROMATIC HYDROCARBONS

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PROCESS FOR THE EXTRACTION AND RECOVERY OF AROMATIC HYDROCARBONS

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7 Claims

ABSTRACT OF THE DISCLOSURE

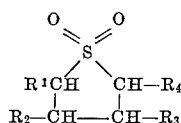
Process for the recovery of aromatic hydrocarbons utilizing the steps of solvent extraction, water washing of the raffinate phase, recovery and reuse of the wash water, and fractionation of the extract phase. Sulfolane is the preferred solvent and benzene is recovered as a preferred product stream.

BACKGROUND OF THE INVENTION

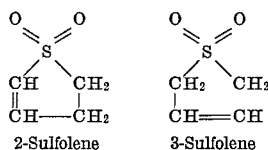
The present invention relates to the solvent extraction of aromatic hydrocarbons from a hydrocarbon charge stream. More particularly, the present invention relates to the recovery of solvent from the raffinate stream produced in the process of extracting aromatic hydrocarbons from a hydrocarbon charge stream. More specifically, the present invention relates to an improved process for the recovery of solvent from the raffinate stream by means of an improved water wash technique.

It is well known in the art that the non-aromatic hydrocarbon raffinate which leaves the extraction zone of an aromatic hydrocarbon extraction process contains contaminating quantities of solvent. This solvent which contaminates the raffinate stream must be recovered not only because it may interfere with subsequent raffinate processing or ultimate raffinate use, but also because continual loss of solvent is a prohibitive economic expense in a commercial aromatic extraction process utilizing modern technology.

A typical solvent which is utilized in commercial aromatics extraction plants and which may be recovered in accordance with the practice of this invention is a solvent of the sulfolane-type. This solvent possesses a five membered ring containing one atom of sulfur and four atoms of carbon, with two oxygen atoms bonded to the sulfur atoms of the ring. Generically, the sulfolane-type solvents may be indicated as having the following structural formula:



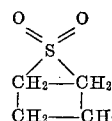
wherein R₁, R₂, R₃, and R₄ are independently selected from the group comprising a hydrogen atom, an alkyl group having from one to ten carbon atoms, an alkoxy radical having from one to eight carbon atoms, and an arylalkyl radical having from one to twelve carbon atoms. Other solvents which may be included within this process are the sulfolenes such as 2-sulfolene or 3-sulfolene which have the following structures:



Other typical solvents which have a high selectivity for separating aromatics from non-aromatic hydrocarbons and which may be processed within the scope of the

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present invention are 2-methylsulfolane, 2,4-dimethylsulfolane, methyl 2-sulfonyl ether, n-aryl-3-sulfonyl amine, 2-sulfonyl acetate, diethylene glycol, various polyethylene glycols, dipropylene glycol, various polypropylene glycols, dimethyl sulfoxide, N-methyl pyrrolidone, etc. The specifically preferred solvent chemical which is processed within the scope of the present invention is sulfolane, having the following structural formula:



Because the typical solvents which are utilized in aromatics extraction are water soluble, it is the practice of the art to extract the solvent from the raffinate stream by washing with water in a subsequent contactor. The extraction of the solvent from the raffinate with water may be undertaken in any suitable liquid-liquid contacting means, as in a tower containing suitable packing such as Berl Saddles or Raschig Rings, or in a tower containing suitable trays, or in a rotating disc contactor (RDC). The solvent may then be readily recovered from the aqueous solution by distillation.

It has been discovered in the commercial aromatics extraction units that the recovery of sulfolane-type solvent from the raffinate by extraction with water does not correspond to the recovery which is to be anticipated based upon solubility data, and the assumption of reasonable efficiency of the extractor. Thus, the loss of sulfolane in the raffinate product has been found to be from five to eight times as great as anticipated, and this loss is greatly above what is economically desirable.

SUMMARY OF THE INVENTION

Therefore, it is an object of the present invention to provide a process for the extraction and recovery of aromatic hydrocarbons from a feed mixture containing aromatic and non-aromatic hydrocarbons with a sulfolane-type solvent.

It is another object of this invention to provide an improved process for the recovery of solvent from the raffinate stream utilizing water washing in a facile and economical manner.

It is a still further object of this invention to provide a process for the production of a raffinate product stream from an aromatic extraction process which is substantially free of solvent contaminant.

Accordingly, the present invention provides a process for the extraction and recovery of aromatic hydrocarbons from a feed mixture containing aromatic and non-aromatic hydrocarbons with a sulfolane-type solvent which comprises the steps of: (a) introducing said feed mixture into a solvent extraction zone maintained under aromatic hydrocarbons with a sulfolane-type solvent presence of said sulfolane solvent sufficient to produce an extract phase comprising said solvent having aromatic hydrocarbons dissolved therein, and a raffinate phase comprising non-aromatic hydrocarbons contaminated with small quantities of said solvent; (b) passing said extract phase into fractionation recovery means under fractionation conditions including the presence of stripping steam from a source hereinafter specified sufficient to produce a distillate vapor fraction comprising aromatic hydrocarbons and steam and a bottoms fraction comprising lean solvent suitable for reuse in said extraction zone; (c) condensing said distillate vapor fraction and producing thereby a product stream comprising aromatic hydrocarbons and an aqueous stream; (d) introducing said raffinate phase into a first wash zone in contact with said aqueous stream of Step (c) under con-

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ditions sufficient to absorb at least a portion of said contaminant into the aqueous stream; (e) withdrawing from said first wash zone a non-aromatic hydrocarbon stream having reduced contaminant content, and a first rich water stream containing solvent; (f) passing said non-aromatic hydrocarbon stream into a second wash zone in contact with a hereinafter specified wash water stream under conditions sufficient to absorb substantially all of the remainder of said solvent contaminant into the wash water stream; (g) removing from said second wash zone a non-aromatic hydrocarbon stream substantially free of solvent contaminant, and a second rich water stream containing solvent; (h) introducing said second rich water stream into a fractionation zone under fractionation conditions sufficient to produce a distillate water stream substantially free of said solvent and a bottoms stream comprising water containing said solvent; (i) passing said distillate water stream of Step (h) into said second wash zone as the specified wash water; and, (j) introducing at least a portion of said first rich water stream and said bottoms stream of Step (f) into said recovery means of Step (b) as the specified source of stripping steam.

In essence, therefore, it can be seen that the present invention utilizes a two-stage water wash technique of the raffinate stream which operates in conjunction with a separate water distillation means for the production of separate and distinct wash waters for use in the two-stage water washing technique. In addition, it can be readily seen that the present invention embodies the unique concepts of water reuse in a facile and economical manner.

DETAILED DESCRIPTION OF THE INVENTION

As a broad general class, suitable feedstocks for the satisfactory practice of this invention include fluid mixtures having a sufficiently high concentration of aromatic hydrocarbons to economically justify recovery of these aromatic hydrocarbons as a separate product stream. The present invention is particularly applicable to hydrocarbon feed mixtures which contain at least 25% by weight aromatic hydrocarbons. A suitable carbon number range for the feedstock is from about 6 carbon atoms per molecule to about 20 carbon atoms per molecule and, preferably, from about 6 to 10 carbon atoms per molecule. One suitable source of feedstock is the debutanized reactor effluent from a conventional catalytic reforming process unit. Another suitable source of feedstock is the liquid by-product from a pyrolysis gasoline unit which has been hydrotreated to saturate olefins and diolefins thereby producing an aromatic hydrocarbon concentrate suitable for the solvent extraction technique described herein. Typically, the feedstock from a catalytic reforming process contains single ring (monocyclic) aromatic hydrocarbons comprising a wide boiling mixture of benzene, toluene, and xylenes. These single ring aromatic hydrocarbons are also mixed with the corresponding paraffins and naphthenes which have been produced from such a catalytic reforming unit.

As previously mentioned, the preferred solvent which may be utilized in the present invention is a solvent of the sulfolane-type. Since this solvent is an article of commerce and is well known to those versed in the solvent extraction art, greater detail thereof need not be presented at this time.

The aromatic selectivity of the solvent can usually be enhanced by the addition of water to the solvent. Preferably, the solvents utilized in the practice of this invention contain small quantities of water in order to increase the selectivity of the overall solvent phase for aromatic hydrocarbons without reducing substantially the solubility of the solvent phase for aromatic hydrocarbons. The presence of water in the solvent composition further provides a relatively volatile material which is distilled from the solvent in the subsequent ex-

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tractor-stripper following the extraction zone, more fully discussed hereinafter, to vaporize the last traces of non-aromatic hydrocarbons from the solvent stream by steam distillation. Accordingly, the solvent composition of the present invention preferably contains from about 0.1% to about 20% by weight water and, preferably, about 0.5 to about 1.0% by weight depending upon the particular solvent utilized and the process conditions at which the extraction zone and the extractor-stripper are operated.

The solvent extraction zone of the present invention is operated at elevated temperature and sufficiently elevated pressure to maintain the feedstock, the solvent, and any reflux streams in liquid phase. Typically, suitable temperatures, when using sulfolane as the solvent, are within a range from about 80° F. to about 400° F. and, preferably, from about 175° F. to about 300° F. Similarly, suitable pressures are generally within the range from about atmospheric pressure up to about 400 p.s.i.g. and, preferably, from 50 to 150 p.s.i.g.

This invention also embodies the concept of displacement of non-aromatic hydrocarbons from the extract phase at the lower end of the extraction zone by utilizing the technique of a non-aromatic hydrocarbon containing reflux at that point. It is distinctly preferred that this reflux stream comprise relatively light non-aromatic hydrocarbons, but may contain significant quantities of aromatic hydrocarbons, e.g. from 30% to 60% by weight. In other words, the extractive distillation column following the extraction zone is operated in such a manner that a reflux stream is obtained which comprises a concentrate of non-aromatic hydrocarbon components which were left in the extract phase from the extraction zone.

The amount of reflux introduced into the lower end of the extraction zone may be varied considerably depending upon the degree to which non-aromatic hydrocarbons are being rejected in the extraction zone. It is preferred that the relatively light non-aromatic reflux introduced into the lower end of the extraction zone be at least 10% by volume of the extract phase in order to effectively displace non-aromatic hydrocarbons from the extract phase into the raffinate phase.

The extractive distillation column following the extraction zone utilizes the extract phase as feedstock and is operated at moderate pressures and sufficiently high reboiler temperatures in order to vaporize all of the non-aromatic hydrocarbon material and a portion of the aromatic hydrocarbons, water, and solvent out of the bottom portion of this column. It is preferred that this first distillation column be operated substantially as a stripper column although fractionation or separation does, in fact, take place therein; that is, the extract phase should be fed into this column at the upper portion thereof in order to provide maximum stripping to take place in the column. In order for extremely high purity aromatic hydrocarbons to be ultimately obtained, it is essential that the extractive stripper column be operated in a manner to prevent all except minute traces of non-aromatic hydrocarbons from being withdrawn in the bottoms product stream from the lower end of this column.

Typically, the extractive stripper will be maintained under pressures from atmospheric to about 100 p.s.i.g., although generally the top of the stripper column is maintained at from 7 p.s.i.g. to about 20 p.s.i.g. The reboiler temperature maintained in the extractive stripper is, of course, dependent upon composition of the extract phase feed thereto and the solvent. The column is arranged to take only an overhead fraction and the bottoms fraction as separate product streams. Those skilled in the art, from a knowledge of the prior art and the teachings presented herein, are well versed in the operation of an extractive stripper column of this type and, therefore, additional details thereof need not be presented here.

The aromatic and solvent recovery column is operated at low pressures and sufficiently high temperatures to dis-

till the aromatic hydrocarbons overhead as a distillate fraction thereby producing a bottoms fraction comprising lean solvent which is generally suitable for reuse in the solvent extraction zone. Again, the precise choice of operating conditions depends upon the feedstock characteristics including aromatic hydrocarbon content and the composition of the solvent. Preferably, the top of the aromatic recovery column is operated at about 100 to about 400 mm. Hg absolute. These subatmospheric pressures must be employed in order to maintain a sufficiently low reboiler temperature to avoid thermal decomposition of the solvent, particularly when the solvent is of the sulfolane-type. Preferably, the reboiler temperature should be maintained below about 360° F. when using saturated sulfolane as the solvent.

Returning now to the operation of the extractive stripper column: the overhead stream from the extractive stripper column is in the vapor state and comprises primarily non-aromatic hydrocarbons of the naphthene and/or paraffin type. Typically, this vapor stream together with a vapor stream from a water stripper column, hereinafter described are condensed in a common condenser thereby producing a combined hydrocarbon stream and a water stream. It is this condensed hydrocarbon stream which is preferably utilized as reflux in the extraction zone in the manner previously discussed.

Returning to the solvent extraction zone description: the raffinate leaves the aromatic extraction zone at an elevated temperature, is cooled, and passed into a first water wash column. This first water wash column, typically, is a vertically disposed vessel containing conventional liquid-liquid contacting apparatus, such as Berl Saddles and other packing material. The cooled raffinate stream enters the lower end of the column and passes upwardly in counter-current fashion in contact with a first water wash stream, the source of which is hereinafter discussed, which is introduced into the upper portion of the column. Suitable operating conditions are maintained in the first water wash column so that, preferably, at least a significant portion of solvent contaminant which was in the raffinate phase is absorbed into the water phase. Thus, a first rich water stream containing the extracted sulfolane is withdrawn from the bottom portion of the first water wash zone, and a hydrocarbon stream having a reduced solvent contaminant content is withdrawn from the upper portion of the first water wash column.

The hydrocarbon stream comprising the hydrocarbons of the raffinate phase, and having a significantly reduced solvent content, is then passed into a second water wash zone, similarly constructed to the first water wash zone, such that the hydrocarbon stream is countercurrently contacted with a second water wash stream, from a source hereinafter described, under conditions sufficient to produce a non-aromatic product stream substantially free of solvent as an overhead stream, and a second rich water stream containing extracted solvent which is withdrawn from the second wash zone at the lower end thereof.

In the practice of the present invention the first and second rich water streams are handled in separate ways. The first rich water stream is withdrawn from the first wash zone and is passed into a water stripper column which is operated as a steam stripper under conditions sufficient to strip out and remove residual hydrocarbons from the first rich water stream. The overhead from the water stripper column, containing a concentrate of the hydrocarbons, is withdrawn as a vapor stream and admixed with the previously mentioned vapor stream from the extractive stripper column and commonly condensed as hereinabove described. The bottom portion of the water stripper comprises water containing sulfolane and is conventionally introduced into a steam generator wherein it is converted into steam for use in the aromatic and solvent recovery column previously mentioned. Therefore, in a preferred embodiment of this invention, the bottoms from the water stripper column are intro-

duced as steam into the aromatic recovery column for use as stripping steam therein.

The second rich water stream which is withdrawn from the second water wash column is passed into a separate fractionation column which is maintained under distillation conditions including reboiling of the bottoms and reflux introduction into the top of the column. Operating conditions are maintained in this second rich water fractionation column, such as 230° F. and 20 p.s.i.a. in the bottom thereof, sufficient to produce a distillate fraction comprising water substantially free of solvent. The distillate fraction is then passed into the upper portion of the second wash column as the second wash water in the manner discussed hereinabove. The bottom from the fractionation column, containing water contaminated with significant quantities of sulfolane, is introduced into a steam generator for the generation of steam therein in a manner so that the generated steam is also introduced into the solvent and aromatic recovery column together with the steam generated from the bottoms of the water stripper column previously mentioned.

Returning now to the aromatic and solvent recovery column: the overhead from the recovery column comprises substantially pure aromatic hydrocarbons and steam as a vapor fraction. The vapor fraction is condensed into an aromatic hydrocarbon product stream which is separated from the condensed steam or condensate. The aromatic hydrocarbons are withdrawn and recovered as a separate product stream. The condensate is withdrawn and introduced into the first wash column as the specified first wash water for contacting of the raffinate phase in the manner discussed hereinabove. If desired, a portion of the condensate may be passed directly into the second rich water fractionation column as additional feed thereto. This latter alternative may be utilized if a significant quantity of wash water is needed in the second water wash column.

In summary, therefore, the present invention provides a method for the extraction and recovery of aromatic hydrocarbons which encompasses a novel water handling scheme operating in conjunction with a novel raffinate water wash technique so that not only may high quality aromatic hydrocarbons be produced, but also a non-aromatic hydrocarbon product stream which is substantially free of solvent contaminant. It is to be noted that the water circuit is arranged so that contaminating quantities of non-aromatic hydrocarbons are not introduced into the aromatic recovery column which, if permitted to happen, would contaminate and lower the purity of the recovered aromatic hydrocarbons. It is also to be noted that the water circuit of the present invention permits maximum recovery of the solvent so that significant economy of operation in terms of minimum solvent loss may be realized.

The invention may be further understood with reference to the appended drawing which is a schematic representation of apparatus for practicing one embodiment of the invention.

DESCRIPTION OF THE DRAWING

Referring now to the drawing, a hydrocarbon feedstock containing aromatic hydrocarbons and non-aromatic hydrocarbons, such as the desired product from a conventional catalytic reforming unit, comprising benzene, toluene, and xylene mixed with corresponding naphthenes and paraffins enters the system via line 10 and introduced into solvent extraction zone 11. Aqueous sulfolane as the lean solvent enters extractor 11 at an upper portion thereof via line 12 and a relatively light nonaromatic hydrocarbon reflux, from a source hereinafter described, enters extractor 11 at the lower end thereof via line 13. The raffinate stream comprising a concentrate of non-aromatic hydrocarbons contaminated with, say, from 1% to 5% by volume sulfolane is withdrawn from extractor 11 via line 28 for further processing in accordance with

the practice of this invention more fully developed hereinbelow.

An extract phase comprising sulfolane solvent having aromatic hydrocarbons dissolved therein and which is contaminated with small amounts of non-aromatic hydrocarbons, such as the corresponding naphthenes and paraffins, is withdrawn from extractor 11 via line 14, admixed with additional lean solvent from line 15, and the total admixture passed into extractive stripper column 17 via line 16. Sufficient separation of distillation conditions, as previously mentioned, are maintained in extractive stripper 17 to produce a bottoms fraction comprising solvent having dissolved therein the desired aromatic hydrocarbons, such as benzene, toluene, and xylene, said bottoms being removed from distillation column 17 via line 20.

The distillation conditions in extractive stripper 17 are also sufficient to produce a distillate or overhead fraction comprising essentially all of the non-aromatic hydrocarbons, aromatic hydrocarbons, and solvent. This overhead vapor fraction is withdrawn from stripper 17 via line 18, admixed with an overhead vapor fraction from a water-stripper, more fully developed hereinbelow, from line 19, condensed for the removal of water by means not shown, and the hydrocarbon phase passed via line 13 as reflux in extractor 11, as previously mentioned.

Referring now to the solvent and aromatic hydrocarbon stream in line 20: this material is passed into aromatic and solvent recovery column 21 which is maintained under conditions sufficient to separate the aromatic hydrocarbons from the solvent phase. The aromatic hydrocarbons are concentrated as a distillate fraction in admixture with steam and removed from recovery column 21 via line 22. The operation of recovery column 21 includes the use of steam stripping on the column in order to remove the final traces of aromatic hydrocarbons from the solvent. Therefore, the lower end of column 21 includes inlet loci for the introduction of steam from a source hereinafter disclosed and the bottoms product from column 21 contains the desired solvent plus water in sufficient amounts such that this bottom material in line 12 comprises lean solvent suitable for reuse in the extraction zone. The lean solvent is passed via line 12 together with makeup lean solvent from line 33, if any, into the upper portion of extractor 11 in the manner previously discussed. Also, as needed, a portion of the material in line 12 is diverted via line 15 and 16 into extractive distillation column 17 in the manner previously discussed.

The material in line 22 contains a concentrate of aromatic hydrocarbons and steam. This vapor stream is admixed with makeup water, as needed, if any, from line 23 condensed by means not shown, and passed via line 24 into accumulator 25. Accumulator 25 is maintained under conditions sufficient to separate the steam condensate from the aromatic hydrocarbons thereby producing an aromatic hydrocarbon product stream which is withdrawn from the system via line 26 and a steam condensate fraction which is withdrawn from accumulator 25 via line 27 for use in the raffinate water wash technique more fully developed hereinbelow.

Returning now to extractor 11: the raffinate phase which is withdrawn from extractor 11 via line 28 contains primarily non-aromatic hydrocarbons together with small amounts of solvent and aromatic hydrocarbons. This raffinate stream is introduced into first wash column 29 which may contain any suitable liquid-liquid contacting means, such as Berl Saddles or Raschig Rings or may comprise a tower containing suitable tray devices, or containing a rotating disc contactor. A first water wash stream comprising the steam condensate from the aromatic recovery column is introduced into the upper portion of first wash column 29 via line 27. The first water wash stream passes in downward fashion in intimate contact with the upflowing raffinate stream in such a manner that at least a significant portion of the contaminating solvent is absorbed into the aqueous phase. The resulting

washed raffinate stream comprising non-aromatic hydrocarbons having reduced sulfolane content leaves wash column 29 via line 34 and is passed into separate wash column 35 which may be identical to the configuration of wash column 29. A second water wash stream substantially free of sulfolane solvent and obtained from a source hereinafter specified is introduced into wash column 35 via line 40. Suitable contacting conditions are maintained in wash column 35 so that substantially all of the remaining sulfolane solvent contaminant is extracted by the water wash stream thereby producing a washed raffinate product stream substantially free of solvent which is withdrawn from the system via line 36.

The bottom aqueous stream from wash column 35 contains water and the solvent which has been extracted. This second rich water stream is removed from wash column 35 via line 37 and as needed admixed with water from line 38 and passed into fractionation column 39 which is maintained under water distillation conditions. The operating conditions are sufficient to produce an overhead water fraction substantially free of sulfolane which is removed from column 39 via line 40 and passed into wash column 35 in the manner previously discussed. The bottoms in column 39 comprises water which contains the extracted sulfolane solvent. This bottoms material is removed from column 39 via line 41 and passed into a steam generator, not shown, for the production of steam which is introduced into recovery column 21 in the manner previously discussed. It is to be noted that the material in line 41 is free of non-aromatic hydrocarbons and, therefore, in steam produced therefrom would not offer a contaminant to the aromatic hydrocarbons which are being distilled in column 21.

Returning now to first wash column 29: the aqueous stream accumulated in the lower portion of column 29 contains water which has extracted a significant quantity of the sulfolane contaminant from the raffinate phase. It also may contain significant quantities of entrained non-aromatic hydrocarbons and in some cases a small amount of aromatic hydrocarbons. Accordingly, the material in line 30 is passed into water stripper column 31 which operates under hydrocarbon stripping conditions including the introduction of steam in such a manner that the overhead distillate fraction produced comprises water, non-aromatic hydrocarbons, aromatic hydrocarbons, if any, and a small amount of solvent. This overhead distillate fraction is removed via line 19 and admixed with the overhead from the extractive distillation column 17 from line 18 and the hydrocarbon phase processed, in the manner previously described, as reflux into extractor 11 via line 13. The bottoms material from water stripper 31 contains water and sulfolane solvent and is passed via line 32 into a steam generator, not shown, for the production of steam therefrom which steam is also introduced into aromatic and solvent recovery column 21 for use therein as stripping steam in the manner previously discussed.

It was found by operating the present invention in the manner described that the raffinate in line 36 will contain less than 5 parts per million of sulfolane solvent, and typically will contain less than 1 part per million, e.g. 0.5 part per million of sulfolane. It was also found in a commercial version of this invention that as much as 50 to 100 pounds per day of sulfolane solvent could be saved over the processing schemes practiced by the prior art heretofore.

PREFERRED EMBODIMENT

Therefore, from the description presented thus far, a preferred embodiment of this invention provides a process for the extraction and recovery of monocyclic aromatic hydrocarbons from a feed mixture containing aromatic and non-aromatic hydrocarbons which comprises the steps of: (a) introducing said feed mixture into a solvent extraction zone maintained under aromatic hydrocarbon ex-

traction conditions including the presence of a sulfolane-type solvent sufficient to produce an extract phase comprising said solvent having aromatic hydrocarbons dissolved therein and contaminated with non-aromatic hydrocarbons, and a raffinate phase comprising non-aromatic hydrocarbons contaminated with small quantities of said solvent; (b) passing said extract phase into an extractive distillation zone under conditions sufficient to produce a first overhead fraction comprising a concentrate of non-aromatic hydrocarbons, and a first bottoms fraction comprising solvent having aromatic hydrocarbons dissolved therein; (c) passing said bottoms fraction into fractionation means maintained under distillation conditions including the presence of stripping steam from a source hereinafter specified sufficient to produce a second overhead fraction comprising a vapor said monocyclic aromatic hydrocarbons and steam, and a second bottoms fraction comprising lean solvent suitable for reuse in said extraction zone; (d) condensing said second overhead fraction thereby producing a product stream of monocyclic aromatic hydrocarbons, and an aqueous condensate stream; (e) introducing said raffinate phase into a first water wash zone in contact with at least a portion of said condensate stream of Step (d) under conditions sufficient to absorb at least a portion of the solvent contaminant into the condensate stream; (f) withdrawing from said first wash zone a non-aromatic hydrocarbon stream having reduced solvent contaminant content, and a first rich water stream containing solvent and small quantities of non-aromatic hydrocarbons; (g) passing said non-aromatic hydrocarbon stream into a second water wash zone in contact with a hereinafter specified wash water stream under conditions sufficient to absorb substantially all of the remainder of said solvent contaminant into the wash water stream; (h) removing from said second wash zone a non-aromatic hydrocarbon stream substantially free of said solvent contaminant, and a second rich water stream containing solvent; (i) introducing said first rich water stream into a stripping zone under conditions sufficient to produce a third overhead fraction comprising non-aromatic hydrocarbons, and a third bottoms fraction comprising water substantially free of hydrocarbon contaminant; (j) introducing said second rich water stream into a fractionation zone maintained under distillation conditions sufficient to produce a fourth overhead stream comprising water having reduced solvent content, and a fourth bottoms fraction comprising water of increased solvent content; (k) passing said fourth overhead stream into said second water wash zone as the specified wash water stream; (l) introducing said third and fourth bottoms fraction said recovery means of Step (b) as the source of said stripping steam; and, (m) recovering said product stream of Step (c).

It is distinctly preferred that the solvent utilized in the practice of this invention comprise sulfolane.

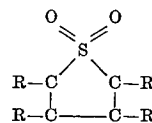
The invention claimed:

1. Process for the extraction and recovery of aromatic hydrocarbons from a feed mixture containing aromatic and non-aromatic hydrocarbons with a sulfolane-type solvent which comprises the steps of:

- (a) introducing said feed mixture into a solvent extraction zone maintained under aromatic hydrocarbon extraction conditions including the presence of said sulfolane solvent sufficient to produce an extract phase comprising said solvent having aromatic hydrocarbons dissolved therein, and a raffinate phase comprising non-aromatic hydrocarbons contaminated with small quantities of said solvent;
- (b) passing said extract phase into fractionation recovery means under fractionation conditions including the presence of stripping steam from a source hereinafter specified sufficient to produce a distillate vapor fraction comprising aromatic hydrocarbons and steam, and a bottoms fraction comprising lean solvent suitable for reuse in said extraction zone;

- (c) condensing said distillate vapor fraction and producing thereby a product stream comprising aromatic hydrocarbons, and an aqueous stream;
- (d) introducing said raffinate phase into a first wash zone in contact with said aqueous stream of Step (c) under conditions sufficient to absorb at least a portion of said contaminant into the aqueous stream;
- (e) withdrawing from said first wash zone a non-aromatic hydrocarbon stream having reduced contaminant content, and a first rich water stream containing solvent;
- (f) passing said non-aromatic hydrocarbon stream into a second wash zone in contact with a hereinafter specified wash water stream under conditions sufficient to absorb substantially all of the remainder of said solvent contaminant into the wash water stream;
- (g) removing from said second wash zone a non-aromatic hydrocarbon stream substantially free of said solvent contaminant, and a second rich water stream containing solvent;
- (h) introducing said second rich water stream into a fractionation zone under fractionation conditions sufficient to produce a distillate water stream substantially free of said solvent, and a bottoms stream comprising water containing said solvent;
- (i) passing said distillate water stream of Step (h) into said second wash zone as the specified wash water; and,
- (j) introducing at least a portion of said first rich water stream and said bottoms stream of Step (h) into said recovery means of Step (b) as the specified source of stripping steam.

2. Process according to claim 1 wherein said sulfolane-type solvent has the structural formula



wherein R is selected from the group consisting of hydrogen, alkyl radical having from 1 to 8 carbon atoms, aryl radical having from 1 to 10 carbon atoms, alkoxy radical having from 1 to 8 carbon atoms, and arylalkyl radical having from 1 to 12 carbon atoms.

3. Process according to claim 2 wherein said solvent comprises sulfolane.

4. Process for the extraction and recovery of monocyclic aromatic hydrocarbons from a feed mixture containing aromatic and non-aromatic hydrocarbons which comprises the steps of:

- (a) introducing said feed mixture into a solvent extraction zone maintained under aromatic hydrocarbon extraction conditions including the presence of a sulfolane-type solvent sufficient to produce an extract phase comprising said solvent having aromatic hydrocarbons dissolved therein and contaminated with non-aromatic hydrocarbons, and a raffinate phase comprising non-aromatic hydrocarbons contaminated with small quantities of said solvent;
- (b) passing said extract phase into an extractive distillation zone under conditions sufficient to produce a first overhead fraction comprising a concentrate of non-aromatic hydrocarbons, and a first bottoms fraction comprising solvent having aromatic hydrocarbons dissolved therein;
- (c) passing said bottoms fraction into fractionation means maintained under distillation conditions including the presence of stripping steam from a source hereinafter specified sufficient to produce a second overhead fraction comprising a vapor containing said monocyclic aromatic hydrocarbons and steam, and a second bottom fraction comprising lean solvent suitable for reuse in said extraction zone;
- (d) condensing said second overhead fraction there-

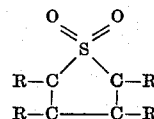
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- by producing a product stream of monocyclic aromatic hydrocarbons, and an aqueous condensate stream;
- (e) introducing said raffinate phase into a first water wash zone in contact with at least a portion of said condensate stream of Step (d) under conditions sufficient to absorb at least a portion of the solvent contaminant into the condensate stream;
- (f) withdrawing from said first wash zone a non-aromatic hydrocarbon stream having reduced solvent contaminant content, and a first rich water stream containing solvent and small quantities of non-aromatic hydrocarbons;
- (g) passing said non-aromatic hydrocarbon stream into a second water wash zone in contact with a hereinafter specified wash water stream under conditions sufficient to absorb substantially all of the remainder of said solvent contaminant into the wash water stream;
- (h) removing from said second wash zone a non-aromatic hydrocarbon stream substantially free of said solvent contaminant, and a second rich water stream containing solvent;
- (i) introducing said first rich water stream into a stripping zone under conditions sufficient to produce a third overhead fraction comprising non-aromatic hydrocarbons, and a third bottoms fraction comprising water substantially free of hydrocarbon contaminant;
- (j) introducing said second rich water stream into a fractionation zone maintained under distillation conditions sufficient to produce a fourth overhead stream comprising water having reduced solvent content, and a fourth bottoms fraction comprising water of increased solvent content;
- (k) passing said fourth overhead stream into said second water wash zone as the specified wash water stream;

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- (l) introducing said third and fourth bottoms fraction into said recovery means of Step (c) as the source of said stripping stream; and,
- (m) recovering said product stream of Step (d).

5 5. Process according to claim 4 wherein said sulfolane-type solvent has the structural formula



10 wherein R is selected from the group consisting of hydrogen, alkyl radical having from 1 to 8 carbon atoms, aryl radical having from 1 to 10 carbon atoms, alkoxy radical having from 1 to 8 carbon atoms, and arylalkyl radical having from 1 to 12 carbon atoms.

15 6. Process according to claim 5 wherein said solvent comprises sulfolane.

20 7. Process according to claim 4 wherein said first overhead fraction of Step (b) and said third overhead fraction of Step (i) are passed into said extraction zone of Step (a) as reflux therein.

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