

[54] **SOLVENT EXTRACTION WITH INCREASED POLAR HYDROCARBON PURITY**

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[51] Int. Cl. **C10g 21/28**

[58] Field of Search **208/321**

[56] **References Cited**
UNITED STATES PATENTS

3,173,966 3/1965 Jones et al. 208/321

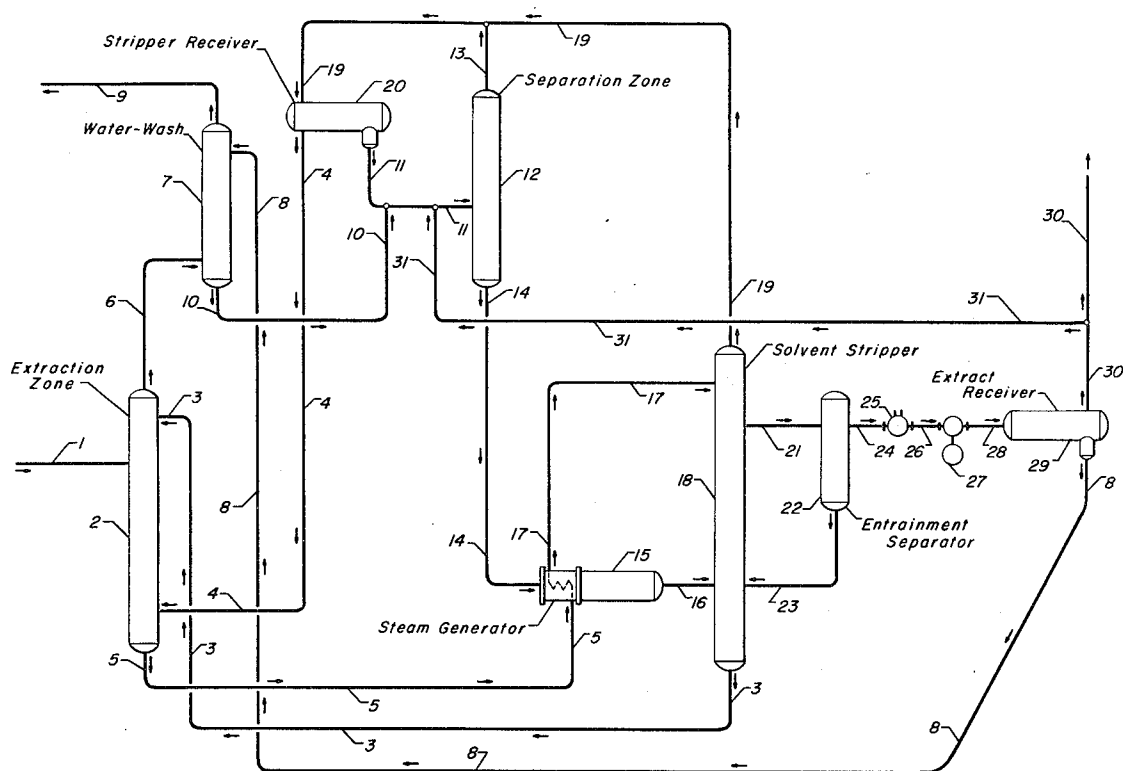
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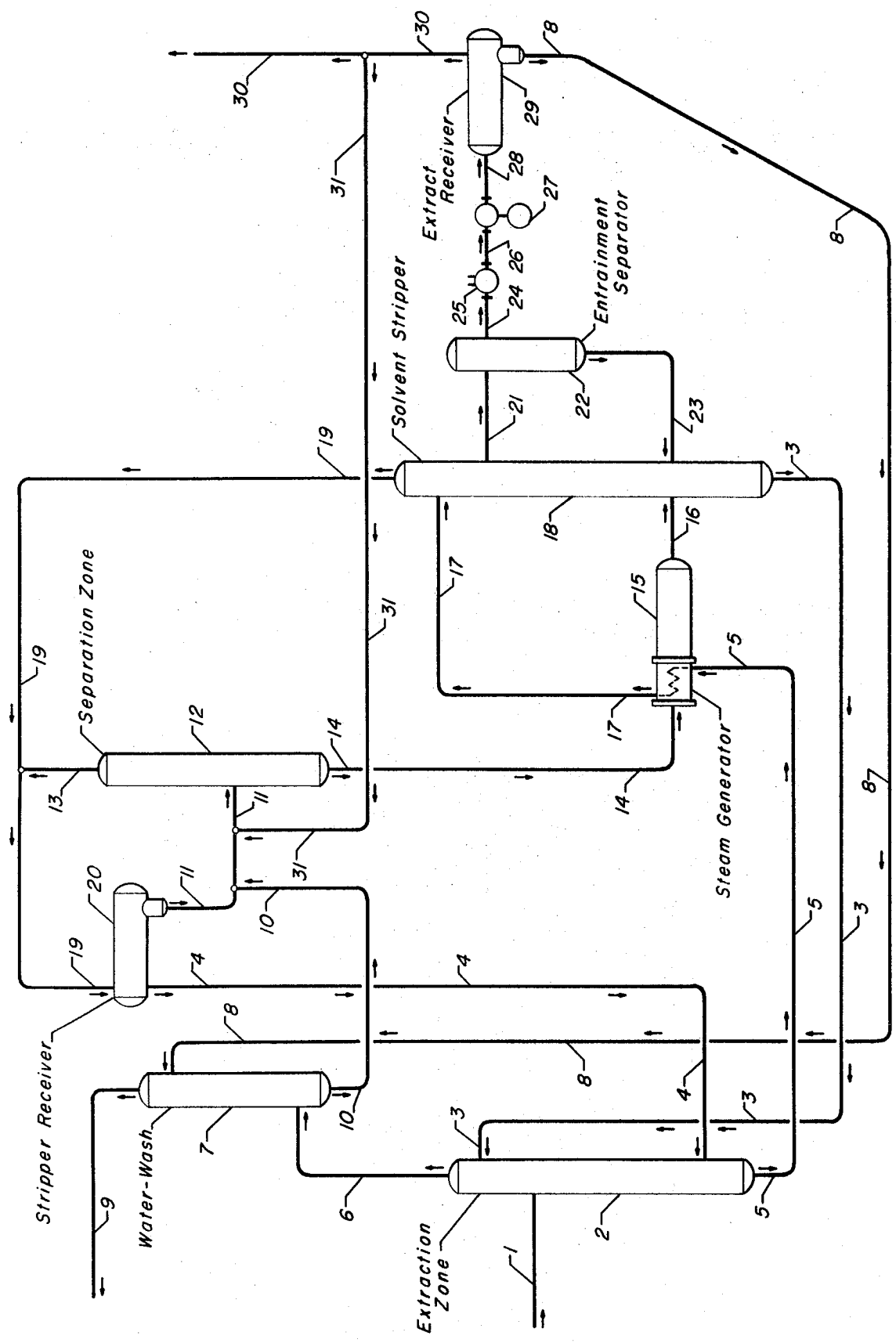
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[57] **ABSTRACT**

A solvent extraction process for effecting the separation of polar hydrocarbons from a mixture thereof with non-polar hydrocarbons. A polar hydrocarbon stream, containing solvent, is passed through two separation zones having a zone of turbulence therebetween, to recover polar hydrocarbons substantially free from solvent. The process is especially adaptable for utilization in the recovery of substantially pure aromatic hydrocarbons from a mixture thereof with non-aromatic hydrocarbons.

11 Claims, 1 Drawing Figure





SOLVENT EXTRACTION WITH INCREASED POLAR HYDROCARBON PURITY

APPLICABILITY OF INVENTION

The invention herein described is intended for utilization in the separation, and ultimate recovery of polar hydrocarbons from a mixture thereof with non-polar hydrocarbons, which separation is effected through the use of a solvent characteristically selective for adsorbing polar hydrocarbons. More specifically, my invention is directed toward the separation and recovery of aromatic hydrocarbons from various mixtures thereof with non-aromatic hydrocarbons, which process utilizes two-stage separation with intermediate turbulence for the purpose of recovering an aromatic concentrate substantially free from solvent.

In the present specification, as well as the appended claims, the use of the terms "polar" and "non-polar" is intended to distinguish between various classes of hydrocarbons wherein one particular type is more polar while another is less polar. For example, in the extraction of aromatics from a mixture thereof with naphthenes and/or paraffins, the latter are considered "non-polar" with respect to the former which are "polar." The process utilizes a solvent which may be indefinitely recycled within the system, separates the desired hydrocarbon products substantially in their entirety from the feed stocks charged to the process and yields the desired polar hydrocarbons in high purity, being substantially free from both solvent and non-polar hydrocarbons. That is, the polar hydrocarbon purity is greater than 99.5% by weight, and the product contains less than about 500 ppm. of solvent.

The present invention is particularly concerned with an improvement in a type of separation process wherein a mixture of various classes of hydrocarbons is introduced into a solvent extraction zone, being countercurrently contacted therein with a solvent selective for the adsorption of aromatic hydrocarbons. A raffinate phase, comprising substantially all of the non-aromatic hydrocarbons in the feed stock (at least about 90.0% by weight), is removed from an end portion of the extraction zone, and an extract phase comprising the aromatic components is removed from the other end portion of the extraction zone, with the aromatic solute being recovered therefrom in a solvent stripping zone through the utilization of steam. The present invention is particularly directed to the further removal of solvent from the aromatic solute, in order to recover an aromatic concentrate virtually free from solvent.

My invention is applicable for use with any hydrocarbon feed stock having a sufficiently high aromatic concentration to justify the recovery thereof — i.e., at least about 25.0% by volume. The overall carbon number range of suitable charge stocks is from about 6 to about 10. These charge stocks will generally include, in addition to C_6 , C_7 and C_8 -aromatics, non-aromatics which can predominate in C_8 and C_9 -paraffins and naphthenes. Exemplary of various sources of suitable charge stocks are the depentanized effluent from a naphtha catalytic reforming unit, coke-oven by-products, wash oils, hydrotreated pyrolysis naphtha, etc.

My inventive concept involves a unique procedure for the removal of solvent from hydrocarbon fractions separated by way of extractive distillation, or combinations of extraction and extractive distillation. In a solvent extraction process, the term "solvent stripping" is

employed to connote the technique wherein a polar hydrocarbon-rich solvent stream is contacted with steam to provide a solvent concentrate substantially free from hydrocarbons, a vaporous stream comprising steam, solvent and hydrocarbons, and a polar hydrocarbon concentrate having a reduced solvent content and containing steam. The present technique is advantageous in that it affords additional removal of solvent from the polar hydrocarbon concentrate emanating from the solvent stripping zone. A distinct improvement is afforded those processes wherein steam is generated, for utilization in the solvent stripping zone, from various water streams separated within the physical confines of the solvent extraction process. The present technique has many advantages over currently-practiced prior art procedures. Principal among these is an increase in the purity of the desired polar hydrocarbon product accompanied by enhanced solvent recovery within the process. Other advantages are hereinafter discussed, and will become evident to those possessing the requisite skill in the appropriate art.

PRIOR ART

It must be recognized that the prior art is prolific with a wide spectrum of solvent extraction processes utilized for effecting the separation of polar and non-polar hydrocarbonaceous mixtures. No attempt will be made herein to exhaustively delineate the appropriate published literature; it will suffice to note several examples which appear to be typical of prior art practices and procedures, and to which the present invention is most suitably applicable. Solvent extraction processes are generally specifically directed to the recovery of aromatic hydrocarbons from a mixture thereof with non-aromatic hydrocarbons. Furthermore, the greater majority of such processes indicate a distinct preference for a water-soluble solvent containing an oxygenated organic compound. A review of the relevant prior art indicates that the prevalent solvent is either a sulfolane-type organic compound, or an alkylene glycol, the latter preferably being a polyalkylene glycol. While most prior art processes are intended for utilization with either of these organic solvents, specific techniques do exist which are peculiar either to one, or the other.

U.S. Pat. No. 3,173,966 (Cl. 260-674) incorporates rectification of rich solvent side-cut vapors, withdrawn from the solvent stripping zone in order to recover substantially solvent-free water for subsequent utilization within the process. In U.S. Pat. No. 3,396,101 (Cl. 208-313), a mixture of charge stock and lean solvent is introduced into a stripping column, from which a non-aromatic overhead stream is withdrawn and introduced into an extraction zone. The resulting rich solvent is passed from the reaction zone to the stripping column as a second feed stream thereto.

U.S. Pat. No. 3,436,435 (Cl. 260-674) involves the utilization of an entrainment separator into which a side-cut aromatic stream, from the solvent stripping zone, is introduced. The process as illustrated further incorporates an integrated system for handling the various water-containing streams. Still another variation, in the integrated process flow of a solvent extraction unit, is that found in U.S. Pat. No. 3,723,256 (Cl. 203-43). Initially, the aromatic hydrocarbon feed is introduced into a distillation column from which a light fraction and a heavier bottoms fraction is recovered. The former is passed into an extractive distillation tower, while

the latter is introduced into a liquid extraction unit. The extract from the liquid extraction unit is stripped of non-aromatic hydrocarbons to produce a non-aromatics free fraction and a non-aromatics containing fraction. The aromatics recovered in admixture with the solvent, from the extractive distillation tower, are passed to a recovery section in admixture with the aromatic-containing fraction from the stripping zone. The overhead stream from the extractive distillation column, in admixture with the non-aromatics from the stripping zone, is passed to the bottom section of the solvent extraction zone, to function therein as a reflux stream.

A perusal of the foregoing illustrations of prior art processes will indicate that the improvements afforded thereby result primarily from a variety of modifications with respect to internal flow of various process streams. That is, a common characteristic of the multitude of solvent extraction processes is the utilization of at least a solvent extraction zone and a solvent stripping zone. For a given solvent extraction unit, designed to process a given quantity of mixed hydrocarbon feed stock, these two vessels, and the required manifolding and miscellaneous vessels appurtenant thereto, are the principal factors determining both erection and operating cost. It may be said, therefore, that economically attractive innovations relate to various techniques utilized with respect to the internal flow of various process streams. The resulting enhancement generally stems from improved and/or simplified unit operations, lower operating utility cost, improved product purity, increased solvent recovery within the process, lower overall initial capital investment, etc. The technique encompassed by my inventive concept is applicable to the foregoing described processes, and affords the indicated advantages therein.

OBJECTS AND EMBODIMENTS

A principal object of my invention is directed towards increased purity of the polar hydrocarbon product stream recovered from a solvent extraction process. A corollary objective resides in increased solvent recovery.

Specifically, my invention affords significant economic advantages when integrated into currently-practiced solvent extraction systems for the separation and recovery of polar hydrocarbons from mixtures thereof with non-polar hydrocarbons.

Therefore, in one embodiment, my inventive concept encompasses a process for the solvent extraction of polar hydrocarbons from mixture thereof with non-polar hydrocarbons, in which process the method of recovering said polar hydrocarbons, substantially free from solvent, comprises the steps of: (a) contacting a polar hydrocarbon-rich solvent stream with steam to provide (i) a first solvent concentrate substantially free from polar hydrocarbons, (ii) a vaporous stream containing steam, solvent and hydrocarbons and (iii) a vaporous first polar hydrocarbon concentrate of reduced solvent content and containing steam; (b) separating said first polar hydrocarbon concentrate, in a first separation zone, to provide (i) a second solvent-rich stream and (ii) a vaporous second polar hydrocarbon concentrate of reduced solvent content, and containing steam; (c) passing said second polar hydrocarbon concentrate through a zone of turbulence at a temperature of about 60°F. to about 180°F.; and, (d) separating the resulting

turbulent polar hydrocarbon concentrate, in a second separation zone, to provide (i) a water concentrate, containing solvent, and (ii) a third polar hydrocarbon concentrate substantially free from solvent.

These, as well as other objects and embodiments of my invention, will become evident from the following detailed description thereof. Briefly, however, with respect to such other embodiments, these involve operating conditions, particular solvents, in-process separations and stream flows, etc. For example, preferred solvents include alkylene glycols, polyalkylene glycols and sulfolane-type organic compounds. In a specific embodiment, directed toward the integration of my inventive concept into a solvent process for the selective separation and recovery of aromatic hydrocarbons from a mixture thereof with non-aromatic hydrocarbons, said aromatic hydrocarbons, substantially free from non-aromatic hydrocarbons and solvent, are recovered by a method which comprises the steps of (a) contacting said mixture with a water-soluble solvent, selective for the adsorption of aromatic hydrocarbons, in a solvent extraction zone, to provide (i) a solvent-rich first extract stream, and (ii) a solvent-lean first raffinate stream; (b) contacting said first raffinate stream with a first water stream to provide (i) a second raffinate stream substantially free from solvent and concentrated in non-aromatic hydrocarbons, and (ii) a second water stream containing solvent and a minor quantity of hydrocarbons; (c) admixing said second water stream with a substantially pure, first aromatic stream and separating the resulting mixture to provide (i) a second aromatic stream, containing non-aromatic hydrocarbons, and (ii) a third water stream substantially free from non-aromatic hydrocarbons; (d) generating steam from said third water stream and contacting said first extract stream therewith in a solvent stripping zone; (e) recovering, from said stripping zone, (i) a vaporous stream containing steam, hydrocarbons and solvent, (ii) a first solvent-rich stream, and (iii) a vaporous second extract stream, concentrated in aromatic hydrocarbons, and containing solvent and steam; (f) separating said second extract stream, in a first separation zone, to provide (i) a second solvent-rich stream, and (ii) a third extract stream of reduced solvent content and containing steam; (g) passing said third extract stream through a zone of turbulence at a temperature in the range of 60°F. to about 180°F.; and, (h) separating the resulting turbulent third extract stream, in a second separation zone to provide a fourth water concentrate containing solvent, and to recover aromatic hydrocarbons substantially free from solvent.

SUMMARY OF INVENTION

Although applicable to a multitude of hydrocarbon mixtures, further discussion will be limited to the separation and recovery of aromatic hydrocarbons from a mixture thereof with paraffins and/or naphthenes. Initially, the mixture of hydrocarbons is contacted with a water-soluble, oxygen-containing solvent particularly selective for the extraction of the aromatic hydrocarbons. There is recovered, from the solvent extraction zone, an extract stream containing aromatic hydrocarbons and a major proportion of the water-soluble solvent (more than 99.0% by weight), and a raffinate stream containing non-aromatic hydrocarbons and a relatively minor proportion (less than about 1.0%) of the water-soluble solvent. The raffinate stream is gen-

erally contacted, in countercurrent flow, with water to recover the solvent and to provide a hydrocarbon concentrate substantially free from solvent. The extract stream is countercurrently contacted with steam in a solvent stripping zone, to remove the water-soluble solvent and to recover an aromatic hydrocarbon concentrate. As hereinbefore set forth, the present invention encompasses a method of further reducing the solvent concentration of the aromatic concentrate.

The aromatic hydrocarbon concentration is generally withdrawn, as a principally vaporous phase, from an intermediate portion of the solvent stripping zone. As such, it contains considerable quantities of steam and solvent, as well as entrained liquid (principally solvent). This aromatic concentrate is introduced into an entrainment separator for the removal of the greater proportion of the entrained liquid phase, rich in solvent, therefrom. The entrainment separation zone may be mechanically arranged within the solvent stripping column, or take the form of a separate vessel externally. The separated entrained liquid phase is returned to the solvent stripping zone; the balance of the extract phase is condensed and introduced, through a zone of turbulence, into an extract receiver for separation into an aromatic-rich product stream and a water concentrate.

Prior art solvent extraction processes have not recognized that a mixed vapor, such as one containing hydrocarbons and water, which is condensed into two liquid phases, in a conventional condensing system, is not in equilibrium. This concept is extremely important when a third component such as a solvent is present, especially when such solvent is completely miscible in the water phase and at least partially miscible in the hydrocarbon phase. This very situation occurs in a solvent stripping zone from which hydrocarbon vapors, water vapors, solvent vapors and some entrained liquid containing all three materials is removed, condensed and phase-separated. It is not unusual to observe that the hydrocarbon phase contains significantly more solvent, up to about 100 times, than would reasonably be predicted from liquid/liquid equilibrium data.

In accordance with the present invention, the aromatic concentrate of reduced solvent content, but containing steam, is passed through a zone of induced turbulence, at a condensed temperature of 60°F. to about 180°F., and introduced into a second separation zone, for the separation of the liquid phases therein. There results a water stream containing solvent and a third aromatic concentrate which is now substantially free from the solvent employed within the process; that is, the aromatic product contains less than 500 ppm. of solvent. The zone of turbulence may be a pump, venturi, orifice, spray nozzle, or combinations thereof, etc., and serves to provide the intimate mixing which is lacking in the initial condensing and phase separation. Liquid/liquid equilibrium will, therefore, be approached and the amount of solvent contained in the ultimate aromatic product is greatly reduced. Up to a 10-fold reduction in solvent content can be reasonably expected.

The foregoing described technique is readily and advantageously integrated into a present-day solvent extraction process. Thus, a mixed hydrocarbon charge stock containing about 70.0% by volume of aromatic hydrocarbons and about 30.0% by volume of non-aromatic hydrocarbons, is introduced into a solvent ex-

traction zone wherein it counter-currently contacts a water-soluble, solvent, such as a polyethylene glycol. A solvent-rich first extract phase is withdrawn from a lower portion of the extraction zone, and a solvent-lean first raffinate phase is withdrawn from an upper portion of the solvent extraction zone. The first raffinate stream, containing a minor proportion of both the water-soluble solvent (about 1.0% to about 5.0%, by weight) and aromatic hydrocarbons, is introduced into a lower portion of a water-wash column wherein it is contacted, countercurrently, with a first water stream. This water-wash step provides a second raffinate stream which is substantially free from water-soluble solvent (less than about 0.05% by weight), and contains only a minor proportion of aromatic hydrocarbons (less than about 2.0%). The first water stream contains solvent and some entrained aromatic hydrocarbons. A second water stream, containing solvent and non-aromatic hydrocarbons is withdrawn from a lower portion of the water-wash zone, admixed with a substantially pure (at least about 95.0%) first aromatic-rich stream, the mixture being introduced into a separation zone. Separation is effected to provide a second aromatic stream containing non-aromatic hydrocarbons and a third water stream containing solvent and a minor quantity of aromatic hydrocarbons, but being substantially free from non-aromatic hydrocarbons. It is this third water stream which is utilized to generate the steam employed in the solvent stripping zone to remove solvent from the solvent-rich first extract phase recovered in the initial solvent extraction zone.

As in prior art processes, some of which have been previously described, the solvent recovered from the lower portion of the solvent stripping zone is recycled, at least in part, within the process to the solvent extraction zone. The overhead stream from the solvent stripping zone, principally comprising hydrocarbons, steam and solvent vapors, is preferably admixed with the aforesaid second aromatic stream, the mixture being introduced into a so-called stripper overhead receiver. The substantially solvent-free aromatic-rich second extract phase is withdrawn from a central portion of the solvent stripping zone, and is passed into an entrainment separator. The second extract phase is principally vaporous, at a temperature in the range of about 150°F. to about 350°F., and contains entrained liquid which is primarily solvent. Following a condensation technique, at a temperature of 60°F. to about 180°F., the extract phase, reduced in solvent content, is passed through a zone of turbulence and into the extract receiver. The latter provides the aromatic-concentrate product, containing less than about 500 ppm. of solvent, and a fourth, solvent-containing water stream. In preferred embodiments, as hereinafter indicated in the description of the accompanying drawing, at least a portion of the aromatic-rich product stream is utilized as the first aromatic stream in admixture with the second water stream. Also, the fourth water stream is recycled, at least in part, within the process as the first water stream introduced into the water-wash zone.

A light hydrocarbon-containing stream is withdrawn from the stripper receiver and utilized as backwash in a lower portion of the initial solvent extraction zone. Also withdrawn from the stripper overhead receiver is a fifth water stream containing some solvent and a minor proportion of hydrocarbons. In a preferred embodiment, this fifth water stream is admixed with the

aforesaid second water stream and first aromatic stream, the mixture being introduced into the separation zone.

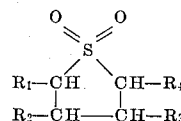
Principal among the multitude of advantages attendant the foregoing described technique is the recovery of aromatic hydrocarbons of exceptionally high purity, and particularly substantially free from the selected organic solvent. A corollary advantage involves the introduction of a lesser quantity of non-aromatics into the solvent stripping zone and, therefore, the aromatic purity is further increased. The overall process enjoys a simplified flow scheme resulting in lower capital investment and subsequent operating costs.

SOLVENTS AND OPERATING CONDITIONS

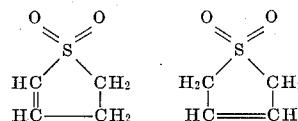
Generally accepted solvents, having solubility selectivity for aromatic hydrocarbons, are water-soluble, oxygen-containing organic compounds. Thus, one particularly preferred category of suitable solvents are those containing, in general, at least one molar substituent selected from such radicals as hydroxyl, amino, cyano, carboxyl or nitro radicals. In order to be effective in a system of extraction, such as the process provided by the present invention, the solvent component having the polar radical must have a boiling point substantially greater than the boiling point of water, added to the solvent composition for enhancing its selectivity; in general, the solvent must also have a boiling point substantially greater than the end boiling point of the hydrocarbon feed stock. In most instances, the solvent composition has a greater density than the hydrocarbon feed stock and is accordingly introduced into the uppermost portion of the solvent extraction zone, thereafter flowing downwardly, countercurrent to the rising hydrocarbon feed stock introduced into the extraction zone at about its mid-point.

Organic compounds suitable as the solvent may be selected from the relatively large group of compounds characterized generally as oxygen-containing compounds, particularly the aliphatic and cyclic alcohols, the glycols and glycol ethers, as well as the glycol esters and glycol ether-esters. The mono- and polyalkylene glycols in which the alkylene group contains from 2 to 4 carbon atoms, such as ethylene glycol, diethylene glycol, triethylene glycol and tetraethylene glycol, propylene glycol, dipropylene glycol, and tripropylene glycol, as well as the methyl, ethyl, propyl and butyl ethers, and the acetic acid esters thereof, constitute a particularly preferred class of organic solvents useful in admixture with water as the solvent composition of the present process. Various phenols such as phenol and resorcinol and their alkyl ethers, such as para-cresol, etc., are also effective solvents for aromatic hydrocarbons. Certain aliphatic nitriles, cyano-substituted ethers and amines, such as acetonitrile, and the diethers and polyalkylene polyamines constitute another group of useful solvents.

Another particularly suitable class of selective solvents are those commonly referred to as the sulfolane-type. By this, I intend a solvent having a 5-membered ring, one atom of which is sulfur, the other four being carbon, and having two oxygen atoms bonded to the sulfur atom. Many of these solvents may be illustrated by the following structural formula:



wherein R_1 , R_2 , R_3 and R_4 are independently selected from the group consisting of a hydrogen atom, an alkyl group having up to 10 carbon atoms, an alkoxy radical having up to 8 carbon atoms and an arylalkyl radical having up to 12 carbon atoms. Other solvents preferably included are the sulfolenes such as 2-sulfolene or 3-sulfolene which have the following structure:



The sulfolane solvents may be made by condensing a conjugated diolefin with sulfur dioxide and then subjecting the resulting product to hydrogenation, alkylation, hydration and/or other substitution or addition reactions. Other solvents which have high selectivity for separating aromatics from non-aromatic hydrocarbons are 2-methylsulfolane, 2,4-dimethylsulfolane, methyl 2-sulfonyl ether, n-aryl-3-sulfonyl amine, 2-sulfonyl acetate.

The aromatic selectivity of the selected solvents is further enhanced by the addition of water. Preferably, the solvents contain a small amount of water dissolved therein to increase the selectivity of the overall solvent phase for aromatic hydrocarbons over non-aromatic hydrocarbons, without reducing substantially the solubility of the solvent phase for aromatic hydrocarbons. The presence of water in the solvent composition provides a relatively volatile material which is distilled from the fat solvent in the extractive stripper to vaporize the last traces of non-aromatic hydrocarbon from the fat solvent stream by steam distillation. The solvent composition contains from about 0.5% to about 25.0% by weight of water, and preferably from about 3.0% to about 15.0% depending on the particular solvent utilized and the process conditions under which the extractor and solvent stripper are operated. By the inclusion of water in the solvent composition, the solubility of aromatic hydrocarbons in the solvent, although somewhat reduced in comparison with a non-aqueous solvent, greatly decreases the solubility of raffinate components in the solvent and also reduces the solubility of solvent in the raffinate stream. Solubility of solvent in the raffinate, however, cannot be completely eliminated and, consequently, the raffinate stream inherently contains more or less solvent, depending upon the proportion of water in the solvent composition. Although the quantity of solvent in the raffinate at any instant is relatively small, the cumulative effect of such small amounts of solvent in a stream removed from the process flow and thus otherwise lost, greatly reduces the efficiency and economy of the solvent extraction process. Recovery can be accomplished efficiently by countercurrently washing the raffinate with water in a separate washing zone from which an aqueous wash effluent is recovered containing the solvent.

The solvent extraction zone is operated at elevated temperature and at a sufficiently elevated pressure to

maintain the feed stock, solvent and backwash streams in the liquid phase. Suitable temperatures are within the range of from 80°F. to about 400°F. and preferably at an intermediate level from about 175°F. to about 300°F. Suitable pressures are within the range of about atmospheric pressure up to about 400 psig. and preferably from about 50 psig. to about 150 psig. Generally, the volume of backwash introduced into the lower point in the extractor is at least 10% by volume of the extract phase leaving the extractor. The solvent to hydrocarbon feed volumetric ratio is in the range of 1.0:1.0 to about 15.0:1.0, and preferably from about 2.0:1.0 to about 10.0:1.0.

The solvent stripper is operated at moderate pressures and sufficiently high reboiler temperatures to drive all the backwash non-aromatic components and some of the aromatics, water and solvent overhead. Typical stripper pressures are from atmospheric to about 100 psig., although the top of the stripper is generally maintained at from about 1.0 psig. up to about 20 psig. The reboiler temperature is dependent upon the composition of the feed stock and the solvent. Generally, stripper bottom temperatures of from 275°F. to about 360°F. are satisfactory.

Other operating conditions will be given in conjunction with the description of one embodiment of the present invention as illustrated in the accompanying drawing. Miscellaneous appurtenances, not believed required, by those possessing the requisite expertise in the appropriate art, for a clear understanding of the present method, have been eliminated from the drawing. The use of details such as pumps, compressors, controls and instrumentation, heat-recovery circuits, valving, start-up lines and similar hardware, etc., is well within the purview of one skilled in the art. It is understood that the illustration does not limit my invention beyond the scope and spirit of the appended claims.

DESCRIPTION OF DRAWING

The accompanying drawing is presented for the purpose of illustrating the method of integrating the present inventive concept into a solvent extraction process designed to separate and recover aromatic hydrocarbons from a mixture thereof with non-aromatic hydrocarbons. Miscellaneous appurtenances, not believed to be required for a clear understanding of the technique involved, has been eliminated from the drawing, or reduced in number.

With reference now to the drawing, the fresh feed charge stock, for example a C₆-plus fraction separated from the effluent of a naphtha catalytic reforming unit, is introduced via line 1 into solvent extraction zone 2 at a locus above the mid-point thereof. The charge stock contains about 41.0% by weight of paraffins, 4.0% naphthenes and 55.0% aromatic hydrocarbons. A solvent-rich stream is introduced into extraction zone 2 by way of line 3 in an amount such that the solvent to hydrocarbon feed volumetric ratio is about 5.25:1.0; the solvent stream contains about 6.0% by weight of water. A light hydrocarbon backwash phase, from line 4, is introduced into a lower portion of the extraction zone and serves to strip the heavier non-aromatic hydrocarbons from the solvent-rich first extract stream withdrawn by way of line 5.

A first raffinate stream containing some aromatic hydrocarbons (about 2.3%) and solvent (about 2.1%) is withdrawn by way of line 6 and introduced thereby into

a lower portion of water-wash column 7. A first water stream, containing a minor amount of both solvent, about 3.0% by weight, and aromatic hydrocarbons, less than about 0.1%, and substantially free from non-aromatic hydrocarbons (less than about 0.01%), is introduced into an upper portion of water-wash column 7 by way of line 8. A second raffinate phase, containing less than 300 ppm. by weight of solvent, is removed from the process by way of line 9. A second water stream, containing the solvent in the first water stream and that removed from the first raffinate stream, and both dissolved and entrained non-aromatic hydrocarbons, is withdrawn by way of line 10 and introduced via line 11 into separation zone 12.

Also introduced into separation zone 12, in admixture with the second water stream in line 10, is a substantially pure first aromatic hydrocarbon from line 31, the source of which is hereinafter set forth. A second water stream, containing at least 90.0% of the non-aromatic hydrocarbons in the second water stream, is withdrawn from an upper portion of separation zone 12 by way of line 13, while a third water stream substantially free from nonaromatic hydrocarbons is withdrawn by way of line 14.

The third water stream is utilized to generate steam in steam generator 15, employing the solvent-rich first extract stream in line 5 as the heat-exchange medium. The cooled extract stream is introduced by way of line 17 into solvent stripping zone 18 wherein it countercurrently contacts the generated steam being introduced by way of line 16. A solvent concentrate is removed by way of line 3 and recycled therethrough to the upper portion of solvent extraction zone 2. A principally vaporous phase, containing steam, hydrocarbons and solvent is withdrawn by way of line 19, admixed with the second aromatic stream in line 13, and introduced into stripper receiver 20.

A second extract stream, of reduced solvent content (about 2.7% by weight), concentrated in aromatic hydrocarbons and containing steam, is withdrawn from an intermediate portion of solvent stripper 18 by way of line 21. The second extract stream, at a temperature of 220°F., containing entrained liquid, is introduced into separator 22, from which entrained solvent is withdrawn by way of line 23 for re-introduction thereby into solvent stripper 18. A third extract stream, containing about 0.5% solvent, is introduced through line 24 into condenser 25, wherein the temperature is decreased to a level of about 140°F. The condensed third extract stream is passed via line 26 through a zone of turbulence, shown in this illustration as motor driven mixer 27. The turbulent stream flows through line 28 into extract receiver 29, from which a fourth water stream, containing substantially all the solvent in the third extract stream, is removed by way of line 8 and preferably recycled, at least in part, as the first water stream introduced into water-wash column 7. The substantially pure aromatic concentrate is withdrawn through line 30. In a preferred embodiment, at least a portion is diverted through line 31 to serve as the substantially pure first aromatic stream combined with the second water stream in line 10.

Stripper receiver 20 serves to provide a light hydrocarbon backwash stream in line 4 which is introduced into the lower portion of extraction zone 2 as hereinbefore set forth. In a preferred embodiment, a fifth water stream is withdrawn by way of line 11, admixed with

the second water stream in line 10 and the first aromatic stream in line 14, the mixture continuing through line 11 into separation zone 12.

The foregoing indicates the method by which the present invention is utilized to separate and recover an aromatic concentrate substantially free from both solvent and non-aromatic hydrocarbons. The product aromatic stream contains about 500 ppm. of solvent, whereas prior art processes absent the zone of turbulence of the present invention, contain about 2,000 ppm. of solvent.

I claim as my invention:

1. In a process for the solvent extraction of polar hydrocarbons from a mixture thereof with non-polar hydrocarbons, the method of recovering said polar hydrocarbons, substantially free from solvent, which comprises the steps of:

- a. contacting said mixture in a solvent extraction zone with a water-soluble solvent selective for the adsorption of polar hydrocarbons to form a polar hydrocarbon-rich solvent stream and a solvent-lean raffinate stream;
- b. contacting said polar hydrocarbon-rich solvent stream from the solvent extraction zone with steam to provide (i) a first solvent concentrate substantially free from polar hydrocarbons, (ii) a vaporous stream containing steam, solvent and hydrocarbons and (iii) a vaporous first polar hydrocarbon concentrate of reduced solvent content, and containing steam;
- c. separating said first polar hydrocarbon concentrate, in a first separation zone, to provide (i) a second solvent-rich stream and (ii) a vaporous second polar hydrocarbon concentrate of reduced solvent content, and containing steam;
- d. passing said second polar hydrocarbon concentrate through a zone of turbulence at a temperature of about 60°F. to about 180°F.; and,
- e. separating the resulting turbulent polar hydrocarbon concentrate, in a second separation zone, to provide (i) a water concentrate, containing solvent, and (ii) a third polar hydrocarbon concentrate substantially free from solvent.

2. The method of claim 1 further characterized in that said solvent is a polyalkylene glycol.

3. The method of claim 1 further characterized in that said solvent is a sulfolane-type organic compound.

4. The method of claim 1 further characterized in that said polar hydrocarbons are aromatic.

5. The method of claim 1 further characterized in that said non-polar hydrocarbons are naphthenes.

6. The method of claim 1 further characterized in that said zone of turbulence comprises a pump.

7. The method of claim 1 further characterized in that said zone of turbulence comprises a venturi.

8. The method of claim 1 further characterized in

that said zone of turbulence comprises an orifice.

9. In a process for the solvent extraction of aromatic hydrocarbons from a mixture thereof with non-aromatic hydrocarbons, the method of recovering said aromatic hydrocarbons, substantially free from non-aromatic hydrocarbons and solvent, which comprises the steps of:

- a. contacting said mixture with a water-soluble solvent, selective for the adsorption of aromatic hydrocarbons, in a solvent extraction zone, to provide (i) a solvent-rich first extract stream, and (ii) a solvent-lean first raffinate stream;
- b. contacting said first raffinate stream with a first water stream to provide (i) a second raffinate stream substantially free from solvent and concentrated in non-aromatic hydrocarbons, and (ii) a second water stream containing solvent and a minor quantity of hydrocarbons;
- c. admixing said second water stream with a substantially pure, first aromatic stream and separating the resulting mixture to provide (i) a second aromatic stream, containing non-aromatic hydrocarbons, and (ii) a third water stream substantially free from non-aromatic hydrocarbons;
- d. generating steam from said third water stream and contacting said first extract stream from said solvent extraction zone therewith in a solvent stripping zone;
- e. recovering, from said stripping zone, (i) a vaporous stream containing steam, hydrocarbons and solvent, (ii) a first solvent-rich stream, and (iii) a vaporous second extract stream, concentrated in aromatic hydrocarbons and containing solvent and steam;
- f. separating said second extract stream, in a first separation zone, to provide (i) a second solvent-rich stream, and (ii) a third extract stream of reduced solvent content and containing steam;
- g. passing said third extract stream through a zone of turbulence at a temperature in the range of 60°F. to about 180°F.; and,
- h. separating the resulting turbulent third extract stream, in a second separation zone to provide a fourth water concentrate containing solvent, and to recover aromatic hydrocarbons substantially free from solvent.

10. The process of claim 9 further characterized in that said first raffinate stream is contacted with at least a portion of said fourth water concentrate as said first water stream.

11. The process of claim 9 further characterized in that said second water stream is admixed with at least a portion of said aromatic hydrocarbons as said substantially pure first aromatic stream.

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