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## SOLVENT REFINING PROCESS

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1 Claim. (Cl. 208—324)

This invention relates to the art of solvent refining hydrocarbon materials and, more particularly, refining a hydrocarbon oil by treating it with a mixture of a liquid oil solvent having selective solvency properties for constituents of the oil and a second liquid having a boiling point higher than that of the first liquid and having a lower solvency for oil. These two liquids may be referred to as a solvent liquid and a carrier liquid which, in accordance with this invention and dependent upon the relative proportions of the two liquids, present a solvent mixture in which either of two constituents of an oil is preferentially soluble and the other constituent of the oil is preferentially insoluble.

This application is a continuation-in-part of my applications, Serial No. 49,625, filed September 16, 1948, Serial No. 96,038, filed May 28, 1949, Serial No. 200,535, filed December 13, 1950, Serial No. 189,733, filed October 12, 1950, and Serial No. 268,697, filed January 28, 1952, all now abandoned.

It is an object of the present invention to upgrade a charging stock by the separation of the aromatic constituents thereof from the non-aromatic constituents thereof in a solvent refining process which provides an extremely complete separation of these constituents and accomplishes this separation with relatively simple and inexpensive equipment.

This process is carried out in its simplest and most economical manner by using a mixture of acetone and water although it is not limited to the use of these two materials. As will be hereinafter described more fully, various materials may be substituted therefor. The use of acetone for refining hydrocarbon oils is known. When acetone alone is used to fractionate oil, it is desirable to use variable temperature in order to impart selectivity to its solvency for the oil. It is also known that the solvency of acetone for a constituent of an oil charge can be decreased while its selectivity is increased by adding water to the acetone instead of by varying temperature. I have found, however, that a solvent of water and acetone can be used in a process to produce a reversal of solvency effect which has heretofore been unknown in that, by properly proportioning the ratio of the oil, water and acetone in different steps of the process, the selective solvency effect of the solvent mixture for the aromatic and non-aromatic constituents of the oil can be in effect reversed, the two constituents of the oil each becoming alternately soluble and insoluble at different steps of the process.

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Another object of this invention is to provide a new process for producing toluene. The boiling point of acetone is 123° F. and is sufficiently low so that it is particularly suitable for the solvent extraction of the aromatic content of gasoline stocks that contain appreciable quantities of toluene. Toluene boils at 229° F., and permits separation of the solvent without fractional or azeotropic distillations.

It is a further object of this invention to provide for a discharge of refined oils which are substantially free of residual acetone or other materials which may have been employed in the solvent refining process.

These and other objects of the invention will become apparent from the following description read in conjunction with the accompanying drawings, in which the single figure is a diagrammatic representation of the operations involved in the solvent refining process.

The figure illustrates the basic process when carried out with acetone and water employed as the solvent liquids. More specifically, the acetone is referred to as the solvent liquid and the water referred to as the carrier liquid. It will be evident that alternate solvent and carrier liquids may be used as will be hereinafter fully discussed.

The oil charge is received through the input pipe line 1 and is drawn into the venturi mixer 20 which is receiving solvent through the line 22. The charge oil is preferably a distillate fraction and may be any desired fraction such as a gas oil or a lighter material. The proportions of the solvent and carrier liquids to each other and other oil charge and the temperatures maintained throughout the process are hereinafter described.

The mixture and solvent passes from the venturi mixer 20 to a normal solubility separator 26. Any type of separator suitable for the separation of two immiscible liquid phases may be used. No specific pressure is required and the pressure preferably used is that which is attained by the transfer of the liquid mixture through the various lines by pumping.

In this first separation stage there is involved pure solubility conditions. The non-aromatic oils are insoluble in the solvent mixture selected and the aromatic oils are soluble in the solvent mixture selected. This step is identical to that disclosed in numerous patents in the prior art.

From the separator 26 an insoluble phase that is rich in non-aromatics, and substantially aromatic free, is passed through line 28 to the heater 32. Any suitable heating means may be employed, but preferably, heat will be supplied to heater 32 as will be hereinafter described in connection with Figure 2. This insoluble non-aromatic phase contains only refined oil and some acetone in solution therewith. The water is substantially completely retained in the soluble aromatic phase.

The acetone carried from the separator 26 by the insoluble non-aromatic oils is vaporized in the heater 32 and the vapors are removed through line 33. The refined non-aromatic oils, which are substantially free of aromatic oils and are also substantially free of solvent, are discharged from the process through line 36.

The soluble aromatic phase, containing also some remaining soluble non-aromatics and the remainder of the



solvent mixture, is removed from the separator 26 through line 27 and is passed to a heater 52. In the heater 52 the soluble phase is raised to the temperature necessary to vaporize acetone. The acetone vapors are removed from the heater 52 through line 53. Only enough acetone is vaporized to provide a solvent concentration and solvent proportions that will cause the separation of a phase that is rich in aromatics and substantially free of non-aromatics. Heat may be supplied to the heater 52 by any convenient means.

The heater 52 may be of any desired construction but is preferably a heater, for example, of the spot evaporator type which will cause considerable turbulence in the solution during the removal therefrom of the removed portion of the acetone. It is desirable that the liquids, either at the time of the separation of the acetone in the heater 52 or immediately thereafter, and prior to the delivery of the liquids to the separator 92, be agitated sufficiently to insure the production of a condition where the oil constituents are in finely dispersed form at the time of their delivery to the separator 92.

In this second stage of separation which occurs in separator 92, there no longer exists a condition of true solubility. The dissolving capacity of the solvent liquid has been reduced to a point where both constituents of the oil come out of true solution. As has been described above, it is well known that, when an oil charge is mixed with a solvent containing a sufficient percentage of acetone, the solvent presents a selective solvency condition in which the non-aromatic constituents are insoluble and the aromatic constituents are soluble. A possible explanation of what takes place in the second stage of the process, that is, in the stage consisting of the heater 52 and the separator 92 is that, as the concentration of acetone is reduced, the remaining non-aromatic constituents first come out of solution and thereafter, as the acetone content is further reduced, the aromatic constituents come out of solution. As these two constituents come out of solution, they exist in the form of minute droplets in finely dispersed form, the droplets being composed individually of either non-aromatic or aromatic oils containing in solution therewith acetone and possibly some water.

An alternate possible explanation is that, with the fairly rapid removal of the acetone which takes place in the heater 52, both the aromatic and non-aromatic constituents of the oil come out of solution substantially simultaneously in the form of dispersed droplets of minute size containing both aromatic and non-aromatic oils in solution in the droplet. There follows then a selective coalescence in which the aromatic constituent of these droplets distill off and combine to form larger droplets of relatively pure aromatic oils which continue to coalesce and form an insoluble phase. The remaining minute droplets containing substantially only non-aromatic oils do not coalesce but remain in a colloidal dispersion of non-coalescent oil.

Thus by properly selecting the ratios of the solvent liquid and the carrier liquid, there is created in the separator 92 a condition in which each of the two oil constituents are in a colloidal or quasi-colloidal or emulsified condition. The separation in this stage takes place by a selective coalescence of the aromatic constituents. As is well known, coalescence is dependent upon boiling temperatures, vapor pressures, and surface tensions of the individual colloidal masses or droplets. In each of the colloidal droplets there exists a solution of the oil constituent and oil solvents. When the proportion of solvent liquid to carrier liquid is properly selected, the condition of the solution in each droplet of the oil constituents will be such that the surface tensions and vapor pressures involved will control the coalescence of the constituents so as to give a selective coalescence of the aromatics and non-coalescence of the non-aromatics. Thus the non-aromatics remain in solution in the form of a colloid, quasi-colloid, or emulsion.

It will be evident that the amount and relative percent-

ages of the solvent liquid and carrier liquid existing in the solvent mixture tends to control or regulate the amount of solvent existing in each of the particles or droplets of each of the constituents of the oil existing in this colloidal solution and, as is known, the amount of solvent in each of these droplets will determine the partial pressure or surface tension of the droplet and thus control, either by hastening or retarding, the rate of coalescence and may similarly prevent coalescence.

While the prior art appears to recognize the fact that there exists ratios of solvent and carrier liquids which will produce a colloidal or emulsified condition of an oil mixed therewith, it has not been recognized in the prior art that solvent proportions may be selected for any particular charging stock which will give rise to a selective coalescence of two constituents of the charging stock such as takes place in the separator 92 as described above. It will be evident that the physical properties of the charging stock and of the individual constituents thereof will affect the ratios of the solvent and carrier liquid required to produce the selected coalescence. In other words, the solvent ratios involved will vary with each charging stock employed as well as varying with various types of solvents which may be employed.

The insoluble phase which is the aromatic oils which have coalesced in the separator 92 and a relatively small percentage of non-aromatic oils and some acetone which is dissolved therein are separated from the remaining non-coalesced colloidal solution existing in separator 92 and are carried out through line 54 to a heater 58. The insoluble aromatics are passed through the heater 58 wherein the acetone is removed therefrom and carried off through line 64. The solvent free aromatics, including some non-aromatics, are discharged from the system through line 66.

The soluble or non-coalesced non-aromatic phase remaining in the reversed solubility separator 92 and the remaining water and acetone are passed out of the separator through line 93 to line 55 wherein the flow is joined by the acetone separated in the heaters. The original solvent mixture is thus restored. This solvent mixture along with the remaining non-aromatics is delivered to a separator 148. The conditions in this separator will be substantially the same as the conditions in the separator 26 and, accordingly, some of the remaining non-aromatics will become insoluble therein and may be removed therefrom through line 152 and delivered to line 28. It will be evident that the separator 148 may be dispensed with, if desired, and the return products from the separator 92 and from the various heaters be returned directly to the venturi mixer 20 for mixture with the incoming charge.

The recombined solvent separated from the remaining non-aromatics in the separator 148 is passed out of the separator 148 through the pump 23 to line 22 and into the venturi mixer 20. The solvent mixture is recycled with the incoming oil charge. Thus a continuous flow process is maintained.

Typical approximate proportions of acetone and water and of aromatic and non-aromatic constituents of the oil are shown numerically in the figure wherein the figures represent parts by volume. A charge of oil representing 10,000 parts is admitted through the venturi mixer 20 with a charge of solvent consisting of 22,000 parts of water and 88,000 parts of acetone. The 120,000 parts pass through separator 26 at room temperature. From the separator the insoluble non-aromatics consisting of 7,000 parts and 1,400 parts of acetone pass to the heater 32 wherein the acetone is driven off and the 7,000 parts of non-aromatic oil are delivered to a suitable catalytic cracking unit.

From the separator 26 the aromatic oils along with the water and remaining acetone pass through heater 52 wherein the temperature is such that 27,930 parts of acetone are driven off at approximately atmospheric pressure. The effect of this change in proportion of the



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volumes of water and acetone is to cause the colloidal or emulsified aromatic oil stage to coalesce and thus to come out of solution whereupon it is removed by separator 92 and delivered to heater 58 wherein the small percentage of acetone carried therewith is removed and 2,300 parts consisting of aromatics containing small quantities of non-aromatics is discharged from the process. The soluble or non-coalesced non-aromatics existing in separator 92 pass with the remaining solvent, which at this stage consists of the original 22,000 parts of water but only 58,140 parts of acetone, join with the condensed acetone returning from the heaters 32, 52 and 58 and pass into separator 148 at room temperature. Thus, within separator 148 the original solvency effect such as existed in separator 126 is reestablished and remaining non-aromatics, now insoluble and representing 700 parts of oil along with 140 parts of acetone, are carried to heater 32, thus adding 140 parts of acetone to the original 1,400 parts driven off by this heater, and adding 700 parts of non-aromatic oil to the 7,000 parts previously mentioned as discharged from the process. There remains then in separator 148 the original 110,000 parts of solvent consisting of 22,000 parts of water and 88,000 parts of acetone which are recycled and mixed with a new oil charge.

While this flow chart is drawn to show a complete separation in one cycle of the solvent, in actual practice, this will not always be the case, but rather, there will be a certain percentage of charge oil recycled with the solvent and there will be a continuous input of charge oil of a volume equal to the sum of the volumes of non-aromatic and aromatic oils discharged from the system. Thus there will be established a continuous process.

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The figures for proportionate volumes shown on the flow chart are approximate values for purposes of illustration. Actually for various charging stocks the approximate practical variation of oil to approximate solvent ratio ranges from a minimum of one volume of oil to  $\frac{1}{8}$  volume of solvent to a maximum of one volume of oil to 19 volumes of solvent. When using acetone and water for the selective solvent, the amount of water in the solvent may range from 10% to a maximum of 64% depending upon the charging stock involved.

The effect of temperature and pressure upon the separation affected in the separator 26 for various oil stocks and solvents is well known. This separation stage has been recognized in a great number of prior patents. The effect of temperature and pressure upon the separation affected in the separator 92 wherein the selective coalescence occurs is not so well known. It will be evident that a complete study of this question would involve the making of a vast number of tests. It is reasonable to assume, however, that coalescence would be influenced by temperature and pressure in that a colloidal solution involving droplets of liquid which are a combination of an oil and solvent in solution in the oil is dependent upon boiling points, partial pressures, and surface tensions of the liquids within the droplets. These factors normally vary with temperature and pressure.

While the foregoing description and the following examples are all set forth as involving substantially atmospheric pressure throughout the various stages of the process, it will be evident that the invention is not limited to being conducted at atmospheric pressure.

The following examples are illustrative and serve to show typical results which are obtained when the invention is carried out in actual practice.

Example Number.....		One	Two	Three	Four
<b>Treating Conditions:</b>					
Solvent: Acetone and Water.....vol..		10	10	10	10
Charge Stock—Catalytic Cycle Stock.....vol..		1	1	1	1
Solvent/Oil Ratio, vol./vol.....		10/1	10/1	10/1	10/1
<b>Solvent—</b>					
Vol. Percent Acetone.....		81.8	80.0	77.8	75.0
Vol. Percent Water.....		18.2	20.0	22.2	25.0
<b>Temperature, ° F.—</b>					
Non-aromatic phase separation.....		72	72	72	72
Aromatic phase separation.....		135	135	135	135
<b>Yields (on Charge Oil):</b>					
<b>1st Non-aromatic (Separator 26)—</b>					
Oil Phase, Vol. Percent.....		83.8	91.7	94.8	98.4
Oil (solvent free), Vol. Percent.....		62.0	67.1	68.3	71.9
<b>2nd Non-aromatic (Separator 148)—</b>					
Oil Phase, Vol. Percent.....		13.2	10.3	10.7	7.9
Oil (solvent free), Vol. Percent.....		9.5	8.2	7.8	7.0
<b>Total Non-aromatic—</b>					
Oil phase, Vol. Percent.....		97.0	102.0	105.5	106.3
Oil (solvent free), Vol. Percent.....		71.5	75.3	76.1	78.9
Solvent removed to reverse solubility effect.....vol..		6.1	6.0	5.8	5.6
<b>Aromatic (Separator 92)—</b>					
Oil Phase, Vol. Percent.....		34.7	30.3	29.1	25.9
Oil (solvent free), Vol. Percent.....		28.5	24.7	23.9	21.1
<b>Inspection Tests:</b>					
Type Stock.....	Feed	Non-aro.	Non-aro.	Non-aro.	Non-aro.
Gravity, Sp. 60/60.....	.8849	.8514	.8581	.8644	.8681
Gravity, ° API.....	28.4	34.7	33.4	32.2	31.5
Color.....	1+	1+	1+	1+	1½—
Flash PM.....	210	192	182	180	124
<b>ASTM Distillation—</b>					
IBP.....	426	440	434	432	420
10%.....	491	503	499	498	500
50%.....	545	556	553	553	552
90%.....	630	634	630	630	628
E.P.....	662	666	660	663	661
Percent Recovery.....	98.0	96.0	96.0	98.0	98.0
Percent Residue.....	1.5	2.5	2.5	1.5	1.5
Percent Loss.....	0.5	1.5	1.5	0.5	0.5
Vis. at 100° F.....	39.8	40.0	41.0	40.0	40.0
Pour, ° F.....	0	20	10	20	10
10% Residue CCR.....	0.025	0.020	0.023	0.020	0.024
Sulfur, Wt. Percent.....	0.128	0.095	0.095	0.088	0.083
Aniline Point, ° F.....	134.0	166.5	160.0	153.5	149.5
Diesel Index.....	38.2	57.8	53.4	49.4	47.1
Cetane Number.....	41.2	51.2	50.4	47.6	45.9
<b>Aromatic</b>					
Type Stock.....		Aromatic	Aromatic	Aromatic	Aromatic
Gravity, Sp. 60/60.....	.9718	.9718	.9685	.9632	.9484
Gravity, ° API.....	14.1	14.1	14.6	15.4	17.7



Example Number.....		Five	Six	Seven	Eight
Treating Conditions:					
Solvent: Acetone and Water.....vol.		10	8	6	6
Charge Stock—Catalytic Cycle Stock.....vol.		1	1	1	1
Solvent/Oil Ratio, vol./vol.....		10/1	8/1	6/1	6/1
Solvent—					
Vol. Percent Acetone.....		81.8	81.8	81.8	77.8
Vol. Percent Water.....		18.2	18.2	18.2	22.2
Temperature, ° F.—					
Non-aromatic phase separation.....		72	72	72	72
Aromatic phase separation.....		135	135	135	135
Yields (on Charge Oil):					
1st Non-aromatic (Separator 26)—					
Oil Phase, Vol. Percent.....		86.4	97.1	99.0	103.3
Oil (solvent free), Vol. Percent.....		62.5	69.0	72.2	74.8
2nd Non-aromatic (Separator 148)—					
Oil Phase, Vol. Percent.....		14.1	8.7	9.7	10.0
Oil (Solvent free), Vol. Percent.....		9.0	7.7	6.9	6.3
Total Non-aromatic—					
Oil Phase, Vol. Percent.....		100.5	105.8	108.7	113.3
Oil (solvent free), Vol. Percent.....		71.5	76.7	79.1	81.1
Solvent removed to reverse solubility effect.....vol.		6.1	4.9	3.7	3.5
Aromatic (Separator 92)—					
Oil Phase, Vol. Percent.....		34.7	28.5	25.3	23.0
Oil (solvent free), Vol. Percent.....		28.5	23.3	20.9	18.9
Inspection Tests:					
Type Stock.....	Feed	Non-aro.	Non-aro.	Non-aro.	Non-aro.
Gravity, Sp. 60/60.....	.8922	.8534	.8586	.8729	.8756
Gravity, ° API.....	27.1	34.3	33.3	30.6	30.1
Color.....	1—	1—	1—	1—	1—
Flash PM.....	190	182	188	154	128
ASTM Distillation—					
IBP.....	420	412	424	408	394
10%.....	455	463	464	459	452
50%.....	492	498	500	496	495
90%.....	549	560	560	555	554
E.P.....	600	596	606	600	602
Percent Recovery.....	98.0	97.5	98.0	98.0	98.0
Percent Residue.....	1.5	1.5	1.0	1.5	1.5
Percent Loss.....	0.5	1.0	1.0	0.5	0.5
Vis. at 100° F.....	34.0	35.8	35.3	34.6	36.1
Pour, ° F.....	0	0	-10	-5	-10
10% Residue CCR.....	0.030	0.015	0.043	0.050	0.028
Sulfur, Wt. Percent.....	0.115	0.05	0.05	0.07	0.07
Aniline Point, ° F.....	134.5	152.0	140.5	125.5	123.0
Diesel Index.....	38.2	52.1	46.9	38.4	37.0
Cetane Number.....	29.8	47.6	44.1	40.3	36.4
Type Stock.....		Aromatic	Aromatic	Aromatic	Aromatic
Gravity, Sp. 60/60.....		.9861	.9986	.9665	.9522
Gravity, ° API.....		12.0	10.2	14.9	17.1

Example Number.....		Nine	Ten	Eleven	Twelve
Treating Conditions:					
Solvent: Acetone and Water.....vol.		2.5	1.5	3.0	2.5
Charge Stock—Catalytic Cycle Stock.....vol.		1.0	1.0	1.0	1.0
Solvent/Oil Ratio, vol./vol.....		2½/1	1½/1	3/1	2½/1
Solvent—					
Vol. Percent Acetone.....		80	80	80	90
Vol. Percent Water.....		20	20	20	10
Temperature, ° F.—					
Non-aromatic phase separation.....		79	79	80	78
Aromatic phase separation.....		135	135	135	135
Yields (on Charge Stock):					
1st Non-aromatic (Separator 26)—					
Oil Phase, Vol. Percent.....		109.8	117.6	106.2	80.6
Oil (solvent free), Vol. Percent.....		86.9	92.3	84.7	62.5
2nd Non-aromatic (Separator 148)—					
Oil Phase, Vol. Percent.....		4.2	2.4	4.8	12.1
Oil (Solvent free), Vol. Percent.....		3.3	1.9	3.8	9.4
Total Non-aromatic—					
Oil phase, Vol. Percent.....		114.0	120.0	111.0	92.7
Oil (solvent free), Vol. Percent.....		90.2	94.2	88.5	71.9
Solvent removed to reverse solubility effect.....vol.		1.5	0.9	1.8	1.5
Aromatic (Separator 92)—					
Oil Phase, Vol. Percent.....		11.8	7.0	13.9	33.8
Oil (Solvent free), Vol. Percent.....		9.8	5.8	11.5	28.1
Inspection Tests:					
Type Stock.....	Feed	Non-aro.	Non-aro.	Non-aro.	Non-aro.
Gravity, Sp. 60/60.....	.8751	.8681	.8724	.8660	.8560
Gravity, ° API.....	30.2	31.5	30.7	31.9	33.8
Flash (PM), ° F.....	164	198	212		
Viscosity at 100° F. SSU.....	36.1	36.3	36.3		36.5
Cloud, ° F.....	40	-2	-8		0
Pour, ° F.....	-15	-10	-15		-15
Color, NPA.....	3+	4½+	5+		4½+
Sulfur, wt. percent.....	0.43	0.39	0.40	0.34	0.29
Aniline Point, ° F.....	120.2	128.7	124.3	130.6	141.1
Cetane Number.....	36.7	42.6			
Cetane Index.....	40.0	42.5	41.0	43.2	47.8
ASTM Distillation—					
IBP.....	374	422	438	419	420
10%.....	486	487	491	487	488
50%.....	523	523	525	523	527
90%.....	573	574	572	571	573
E.P.....	606	608	613	606	609
Percent Recovery.....	98.5	97.0	98.8	99.2	98.5
Percent Residue.....	1.2	0.8	1.0	0.6	1.2
Percent Loss.....	0.3	0.2	0.2	0.2	0.3
Type Stock.....		Aromatic	Aromatic	Aromatic	Aromatic
Gravity, Sp. 60/60.....		.9705	.9141	.9503	.9254
Gravity, ° API.....		14.3	23.2	17.4	21.4



Example Number	Thirteen	Fourteen	Fifteen	Sixteen
<b>Treating Conditions:</b>				
Solvent: Acetone and Water.....vol.	2.5	2.5	2.5	11.0
Charge Stock—Catalytic Cycle Stock.....vol.	1.0	1.0	1.0	1.0
Solvent/Oil Ratio, vol./vol.....	2½/1	2½/1	2½/1	11/1
<b>Solvent—</b>				
Vol. Percent Acetone.....	70	80	80	80
Vol. Percent Water.....	30	20	20	20
<b>Temperature, ° F.—</b>				
Non-aromatic phase separation.....	80	100	49	76
Aromatic phase separation.....	135	135	135	135
<b>Yields (On Charge Oil):</b>				
1st Non-aromatic (Separator 26)—				
Oil Phase, Vol. Percent.....	116.3	111.5	110.6	74.7
Oil (solvent free), Vol. Percent.....	94.4	88.9	88.2	59.3
2nd Non-aromatic (Separator 148)—				
Oil Phase, Vol. Percent.....	1.7	3.5	3.4	12.3
Oil (solvent free), Vol. Percent.....	1.4	2.8	3.0	9.8
<b>Total Non-aromatic—</b>				
Oil Phase, Vol. Percent.....	118.0	115.0	114.0	87.0
Oil (solvent free), Vol. Percent.....	95.8	91.7	91.2	69.1
Solvent removed to reverse solubility effect.....vol.	1.5	1.5	1.5	6.6
<b>Aromatic (Separator 92)—</b>				
Oil Phase, Vol. Percent.....	5.3	9.8	11.1	37.7
Oil (solvent free), Vol. Percent.....	4.2	8.3	8.8	30.9
<b>Inspection Tests:</b>				
Type Stock.....	Feed	Non-aro.	Non-aro.	Non-aro.
Gravity, Sp. 60/60.....	.8751	.8724	.8692	.8438
Gravity, ° API.....	30.2	30.7	31.3	36.2
Flash (PM), ° F.....	164			
Viscosity at 100° F.....	36.1	36.2	36.2	36.8
Cloud, ° F.....	40	2	—2	—
Pour, ° F.....	—15	—10	—15	—10
Color, NPA.....	3+	6—	5+	4—
Sulfur, wt. percent.....	0.43	0.42	0.43	0.36
Aniline Point, ° F.....	120.2	123.3	126.3	151.5
Cetane Number.....	36.7			54.4
Cetane Index.....	40.0	41.0	42.2	52.9
<b>ASTM Distillation—</b>				
IBP.....	374	402	338	456
10%.....	486	487	489	488
50%.....	523	524	524	524
90%.....	573	571	570	568
E.P.....	606	609	609	608
Percent Recovery.....	98.5	98.7	98.7	98.5
Percent Residue.....	1.2	1.0	1.2	1.2
Percent Loss.....	0.3	0.3	0.1	0.3
Type Stock.....		Aromatic	Aromatic	Aromatic
Gravity, Sp. 60/60.....		.9993	.9396	.9440
Gravity, ° API.....		10.1	19.1	18.4

Throughout the foregoing portion of this disclosure the invention has been described as carried out in the presence of a solvent comprising a solution of acetone and water. As noted above, various other materials may be substituted for these two liquids. For example, in place of acetone there may be used methyl acetate-acetone azeotrope or methyl alcohol-methyl acetate-acetone azeotrope. Any of these materials may be employed as the solvent liquid in conjunction with any of the following carrier liquids, namely, water or acetic acid. The acetic acid may also be used in conjunction with acetone. It is possible that methyl acetate, selected ketones or selected alcohols may also be used as solvent liquids in conjunction with any of the aforementioned carrier liquids and that other selected alcohols may be used as carrier liquids in conjunction with any of the abovementioned solvent liquids. If acetic acid or selected alcohols are used as a carrier liquid they may be used with or without the presence of water. It is probable that other equivalents may be employed in place of the acetone or water.

It is noted that the use of acetone with water may be defined as the use of an admixture of water and a ketone, the ketone being completely soluble in the water and the water being completely soluble in the ketone, and the ketone also forming no azeotrope with the water.

Acetone is isomeric with allyl alcohol. Consequently, the use of acetone is representative of ketones and alcohols that are related through saturation isomerism.

As stated above, the temperatures within the system will depend upon the solvents used. For example, water boiling at 212° F. may possibly be used not only with acetone boiling at 133° F. but also with methyl acetate boiling at approximately 140° F. and various selected ketones and alcohols which have boiling temperatures below 212° F. and have greater solubility for the oil than has water. In place of water there may be used materials such as acetic acid boiling at approximately

245° F. The acetic acid may or may not contain water and may be used as a modifier in place of water. Thus, acetic acid may be used with acetone, or possibly, methyl acetone or selected ketones and alcohols. Again it is necessary, however, that the ketones and alcohols selected have boiling temperatures below the boiling temperature of acetic acid and higher solubility for the oil. Certain alcohols may also possibly be substituted for the water, for example, ethyl alcohol having a boiling temperature of approximately 173° F. may be used with or without water as a modifier for acetone, methyl acetone, and selected ketones and alcohols. For example, methyl alcohol having a boiling temperature of 149° F. may possibly be used as a mixed solvent with the ethyl alcohol. Thus, it will be obvious that a wide variety of solvents and temperature conditions may be used without departing from the scope of the invention as disclosed herein.

It will be evident that the boiling to accomplish solvent removal may be carried out under conditions of increased pressure in which case the boiling temperatures would be proportionately increased. If the temperatures and pressures existing throughout the system are varied, it will be evident from the foregoing that in all probability the solvent ratios required will also be varied and that these variations may be made without departing from the scope of the invention as disclosed herein.

It will be evident that various modifications may be made in the sequence of steps of the invention disclosed. For example, the oil charge which is shown in the drawing as being admitted to the system at the point where the solvent is delivered to the separator 26 could be admitted to the liquids entering the reversed solubility separator 92 and the solvents recycled in the manner described. This type of system has been disclosed in my copending patent application, Serial No. 189,773, filed October 12, 1950. It will be evident that these and other modifications may be made to the invention set forth here-



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in without departing from the scope of the invention as set forth in the following claim.

What is claimed is:

The process of refining a hydrocarbon oil including aromatic and non-aromatic constituents comprising admixing the oil charge with a solvent solution including acetone and water, regulating the proportions of the liquids present so as to have all of both oil constituents present dissolved in the solvent solution, thereafter adjusting the proportions of the liquids to provide a ratio of oil to solvent solution of approximately 3 parts of oil to 80 parts of solvent solution and a ratio of water to acetone of approximately 22 parts of water to 59 parts of acetone at atmospheric pressure and at a temperature below approximately 136° F. to give rise to the formation of two liquid phases in which one of the liquid phases comprises an insoluble oil phase produced by coalescence of insoluble aromatic oil and the other of the liquid phases comprises the solvent solution and a dispersion of non-coalescent insoluble non-aromatic oil contained in

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the solvent solution, and separating the two phases thus formed.

# References Cited in the file of this patent

## UNITED STATES PATENTS

1,925,525	Dietrich et al. ....	Sept. 5, 1933
2,045,321	Clarke .....	June 23, 1936
2,047,755	Volck .....	July 14, 1936
2,072,789	Anson .....	Mar. 2, 1937
2,083,511	Tuttle .....	June 8, 1937
2,107,681	Van Dijck .....	Feb. 8, 1938
2,137,499	Moravec .....	Nov. 22, 1938
2,146,147	Keith et al. ....	Feb. 7, 1939
2,149,752	Vickery .....	Mar. 7, 1939
2,173,460	Van Wijk et al. ....	Sept. 19, 1939
2,201,821	Andrews et al. ....	May 21, 1940
2,273,661	Poole .....	Feb. 17, 1942
2,396,299	Sweeney et al. ....	Mar. 12, 1946
2,423,527	Steinschlager .....	July 8, 1947