EXTRACTION OF AROMATICS FROM HYDROCARBON OIL USING N-METHYL 2-PYRROLIDONE AND CO-SOLVENT

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ABSTRACT
The present invention provides a process for extraction of aromatic material from hydrocarbon oil by using a solvent mixture comprising N-Methyl-2-Pyrrolidone (NMP), at least one co-solvent and optionally water, to obtain a raffinate. The process of the present invention lowers operating cost as the cost of the co-solvent employed is lower than that of neat NMP. Another feature of the present invention is that it produces the same quality raffinate as those of neat NMP-water measured by the refractive index but produces higher yield of raffinate at same feed to solvent mixture ratio.
EXTRACTION OF AROMATICS FROM HYDROCARBON OIL USING N-METHYL 2-PYRROLIDONE AND CO-SOLVENT

[0001] This application claims priority benefit from Indian Provisional Application No. 584/DEL/2009, filed on Mar. 25, 2009, the entire content of which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to a process for extraction of aromatic material from hydrocarbon oil by addition of a solvent mixture comprising N-Methyl-2-Pyrrolidone (NMP), at least one co-solvent and optionally water, to obtain a raffinate.

[0003] The raffinate obtained by the process of the present invention is of a higher yield than that obtained by conventional process at the same solvent mixture to feed ratio. The raffinate obtained also maintains the same quality as those obtained by process using neat NMP-water which is measured by the refractive index.

BACKGROUND OF THE INVENTION

[0004] Solvent extraction process is a process employed for the removal of constituents that would have an adverse effect on the performance of the product in use. In petroleum refining industry, all automobile lubricating oils/hydrocarbon oils are subjected to solvent extraction process, to extract the undesirable constituents such as aromatic materials (having low hydrogen to carbon ratio) from the more desirable paraffinic hydrocarbons (having relatively high hydrogen to carbon ratio). Lube distillates rich in aromatic hydrocarbons like benzene, toluene, and the xylenes but with higher carbon number are separated from the paraffinic hydrocarbons with suitable solvents. The process separates the hydrocarbon oil into two phases, a raffinate phase, which contains the paraffinic hydrocarbons and an extract phase, which contains the aromatic materials.

[0005] The process involves the use of solvents such as furfural, phenol and N-methyl-2-pyrrolidone (NMP) which are selective for the aromatic materials present in the hydrocarbon oils feed stream. N-methyl-2-pyrrolidone (NMP) has been used to selectively extract aromatic components from hydrocarbon oils, as disclosed in U.S. Pat. No. 3,929,616, U.S. Pat. No. 4,013,549, U.S. Pat. No. 4,909,927 and U.S. Pat. No. 5,041,206.

[0006] U.S. Pat. No. 4,013,549 discloses an upgradation of lubricating oil stocks by contacting them with a solvent comprising a mixture of N-methyl-2-pyrrolidone (NMP) and phenol. The solvent also contains a minor amount of water. However in this prior art, the increase in raffinate yield is not disclosed. U.S. Pat. No. 4,909,927 discloses use of combination of extraction solvent, such as N-methyl pyrrolidone, phenol, furfural, ethyl benzene or morpholine for removal of aromatic hydrocarbon components from hydrocarbon oils, particularly petroleum oils, lube, transformer, white oil and other specialty oils.

[0007] In U.S. Pat. No. 3,415,743, use of dimethyl formamide and water solvent solution for extraction of cracked cycle oil is disclosed. U.S. Pat. No. 3,929,617 discloses the use of mixture of solvent including furfural, phenol, N-methyl 2-pyrrolidone, dimethyl formamide for extraction of hydrocrackate. However, in both the prior arts, increase in the raffinate yield from hydrocarbon oil on the addition of co-solvent is not disclosed.

[0008] U.S. Pat. No. 5,922,193 discloses addition of ethers or aldehydes to furfural to improve the solvent capacity for debottle necking the extraction unit. It also claims 2 to 3 volume % increase in the raffinate yield during the process. In U.S. Pat. No. 4,273,645, additives such as, sodium dodecylbenzene sulfonate or high molecular weight polyethylene oxide resin is added to improve the selectivity of furfural. It claims less than 3 volume % increase in the raffinate yield at solvent dosage of 250 volume %. Further, in the said patent document, the recovery and material balance of the additive employed is not disclosed. U.S. Pat. No. 6,866,772 discloses use of co-solvent for furfural extraction process to increase raffinates yield but the use of co-solvent with NMP is not discussed.

[0009] Hence there is a need for a process for producing a raffinate by removal of aromatic material from hydrocarbon oil, in a higher yield and a low operational cost.

SUMMARY OF THE INVENTION

[0010] The present invention relates to a process for extraction of aromatic material from hydrocarbon oil, said process comprising contacting the hydrocarbon oil with a solvent mixture to obtain an extract phase and a raffinate product phase, wherein the solvent mixture comprises N-Methyl-2-Pyrrolidone (NMP), with or without water and at least one co-solvent capable of facilitating phase separation; and separating the extract phase from the raffinate product phase, wherein the extract phase contains the aromatic material.

[0011] The present invention further relates to obtaining the raffinate from the raffinate product phase by removing the solvent from the raffinate phase.

[0012] These and other features, aspects, and advantages of the present subject matter will become better understood with reference to the following description and appended claims. This summary is provided to introduce a selection of concepts in a simplified form. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

DETAILED DESCRIPTION OF THE INVENTION

[0013] The present invention relates to a process for extraction of aromatic material from hydrocarbon oil, said process comprising contacting the hydrocarbon oil with a solvent mixture to obtain an extract phase and a raffinate product phase, wherein the solvent mixture comprises N-Methyl-2-Pyrrolidone (NMP), and at least one co-solvent capable of facilitating phase separation; and separating the extract phase from the raffinate product phase, wherein the extract phase contains the aromatic material.

[0014] The present invention further relates to obtaining the raffinate from the raffinate product phase by removing the solvent from the raffinate phase.

[0015] In the present invention, the term ‘aromatic material’ refers to aromatic compounds having low hydrogen to carbon ratio. These materials may be aromatic hydrocarbons like benzene, toluene, and the xylenes but with higher carbon number. The term ‘aromatic material’ will also encompass a single type of aromatic material or a combination of different aromatic materials.
[0016] In the present invention the term ‘raffinate’ is used to define the hydrocarbon oil lean in the aromatic materials, wherein the aromatic materials have been extracted from the hydrocarbon oil by the process of the present invention.

[0017] The process of the present invention provides an increased yield of raffinate with the use of at least one co-solvent along with N-Methyl-2-Pyrrolidone (NMP) by more than 6 wt% than the raffinate obtained by using NMP in an extraction process without the addition of any co-solvent.

[0018] In an embodiment of the present invention, the hydrocarbon oil is a lube oil distillate.

[0019] In another embodiment of the present invention, the hydrocarbon oil is a lube oil distillate comprising 25 wt% to 80 wt% of aromatic material.

[0020] In still another embodiment of the present invention, the hydrocarbon oil is a lube oil distillate comprising 30 wt% to 60 wt% of aromatic material.

[0021] In yet another embodiment of the present invention, the hydrocarbon oil has a boiling point in the range of 150°C to 600°C.

[0022] In another embodiment of the present invention, the hydrocarbon oil has a boiling point in the range of 240°C to 565°C.

[0023] In an embodiment of the present invention, the co-solvent used in the process is an N,N-dimethyl amide.

[0024] In another embodiment of the present invention, the co-solvent used in the process is selected from the group consisting of formamide, N-methyl formamide, N,N-dimethyl formamide, acetamide, N-methyl acetamide, N,N-dimethyl acetamide, Propionamide, N-methyl propionamide and N,N-dimethyl propionamide or mixtures thereof.

[0025] In still another embodiment of the present invention, the co-solvent used in the process is N,N-dimethyl formamide.

[0026] In yet another embodiment of the present invention, the ratio of NMP and co-solvent in the solvent mixture is in the range of 40:60 (w/w) to 90:10 (w/w).

[0027] In another embodiment of the present invention, the ratio of NMP and co-solvent in the solvent mixture is in the range of 50:50 (w/w) to 85:15 (w/w).

[0028] In an embodiment of the present invention, the hydrocarbon oil and solvent mixture are taken in the weight ratio in the range of 1:0.8 to 1:2.5, referred as solvent mixture dosage in the range of 80 wt% to 250 wt%.

[0029] In another embodiment of the present invention, the hydrocarbon oil and solvent mixture are taken in the weight ratio less than 1:2.2, referred as solvent mixture dosage less than 220 wt%.

[0030] In yet another embodiment of the present invention, the hydrocarbon oil and solvent mixture are taken in the weight ratio less than 1:1.8, referred as solvent mixture dosage less than 180 wt%.

[0031] In still another embodiment of the present invention, hydrocarbon oil and solvent mixture are taken in the weight ratio less than 1:1.5, referred as solvent mixture dosage less than 150 wt%.

[0032] In an embodiment of the present invention, the process of extraction is a continuous counter current extraction process.

[0033] In another embodiment of the present invention, the process of extraction is a batch extraction process.

[0034] In an embodiment of the present invention, the solvent mixture comprises NMP and co-solvent with or without water.

[0035] In another embodiment of the present invention, the water in the solvent mixture is in the range of 0.0 wt% to 5.0 wt%.

[0036] In still another embodiment of the present invention, the water in the solvent mixture is in the range of 0.0 wt% to 3.0 wt%.

[0037] In yet another embodiment of the present invention, the water in the solvent mixture is in the range of 0.0 wt% to 1.5 wt%.

[0038] In an embodiment of the present invention, the solvent mixture comprises NMP, co-solvent and water.

[0039] In another embodiment of the present invention, the water in the solvent mixture is in the range of 0.1 wt% to 5.0 wt%.

[0040] In still another embodiment of the present invention, the water in the solvent mixture is in the range of 0.1 wt% to 3.0 wt%.

[0041] In yet another embodiment of the present invention, the water in the solvent mixture is in the range of 0.3 wt% to 1.5 wt%.

[0042] In an embodiment of the present invention, the weight ratio of NMP with water and co-solvent in the solvent mixture is in the range of 50:50 (w/w) to 95:5 (w/w).

[0043] In another embodiment of the present invention, the weight ratio of NMP with water and co-solvent in the solvent mixture is in the range of 65:35 (w/w) to 85:15 (w/w).

[0044] In an embodiment of the present invention, the solvent mixture is recovered and reused in the process.

[0045] In an embodiment of the present invention, the yield of raffinate increases by more than 2 wt% with addition of at least one co-solvent compared to a N-Methyl-2-Pyrrolidone (NMP) extraction process without the addition of any co-solvent.

[0046] In another embodiment of the present invention, the yield of raffinate increases by more than 6 wt% with addition of at least one co-solvent compared to a N-Methyl-2-Pyrrolidone (NMP) extraction process without the addition of any co-solvent.

[0047] The present invention relates to an improved NMP extraction process for the removal of aromatic material from hydrocarbon oil, more particularly from lube oil distillate containing aromatic material by addition of a solvent mixture comprising NMP and at least one co-solvent with or without addition of water.

[0048] NMP is mainly employed because of its high solvent power and complete miscibility with water. Moreover, it is environmentally friendly and the miscibility temperature is low. It can be used for the extraction process at lower solvent to feed ratio as compared to the extraction process where furfural is used. Also, the operating temperature is lower when NMP is used in the solvent mixture as compared to furfural.

[0049] It is a feature disclosed in the present invention that addition of the co-solvent in NMP and water, conducted in a batch process or a continuous countercurrent extraction column facilitates phase separation and increases raffinate yield while maintaining the same raffinate quality as those of neat NMP-water measured by the refractive index but producing higher yield of raffinate at same solvent mixture to feed ratio. It also lowers the operating cost as the cost of the co-solvent employed is lower than that of neat NMP.
In this process, addition of co-solvent, preferably a mixture of N,N-dimethyl amides to NMP and water is done to facilitate phase separation and selectivity, wherein the raffinate yield increases by more than 5 wt % for Inter neutral distillate (IN), feed at solvent mixture dosage less than 250 wt %, preferably at solvent mixture dosage less than 150 wt %.

Similarly, addition of the co-solvent in NMP and water, conducted in a batch extraction setup results in an increase in raffinate yield by more than 2 wt % for Heavy neutral (HN) distillate feed at solvent mixture dosage less than 250 wt %, preferably at solvent mixture dosage less than 180 wt %.

Also, addition of the co-solvent in NMP without water, conducted in a batch extraction setup results in an increase in raffinate yield by more than 3 wt % for IN distillate feed and by 2% in HN distillate at solvent mixture dosage less than 250 wt %, preferably at solvent mixture dosage less than 180 wt %.

The process is applicable to hydrocarbon oils, preferably lube oil distillates. The feedstock typically comprises hydrocarbon oils having initial boiling point of greater than 150°C and a final boiling point of about 600°C. preferably those fractions having a boiling point in the range of about 240°C to 565°C. These lube oil distillate stocks namely, spindle oil (SO), light neutral (LN), inter neutral (IN) and heavy neutral (HN) and deasphalted oil (DAO) are used in this process and these distillates are fractions of vacuum tower.

The characteristics of the product of solvent extraction are very important and consideration of the solvent extraction conditions coupled with the choice of the feed is necessary to achieve a product with desired viscosity and Viscosity Index (VI). Maximum yield of high VI product is achieved by adjusting the extraction severity. The resulting raffinate has a VI of at least about 85, preferably 90 or above. The raffinate (after extraction of aromatic material) contains at the most about 40 wt % of aromatic material, preferably ranging from about 10 to 30 wt %, more preferably from 10 to 20 wt %. The extraction is performed by conventional means, such as in a batch extraction column or multistage counter current system, in a column with packing material or provided with perforated plates or in a column with rotating shaft provided with discs.

The process of the present invention involves the addition of at least one co-solvent to NMP and water or NMP alone to facilitate phase separation, selectivity and increase in raffinate yield. The co-solvent is selected from N,N-dimethyl amides, preferably selected from the group consisting of formamide, N-methyl formamide, N,N-dimethyl formamide, acetamide, N-methyl acetamide, N,N-dimethyl acetamide, propionamide, N-methyl propionamide and N,N-dimethyl propionamide or mixtures thereof, more preferably N,N-dimethyl formamide. The properties of the co-solvent employed for the present invention is listed in Table 1.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Name of Solvent</th>
<th>Melting Point (°C.)</th>
<th>Boiling Point (°C.)</th>
<th>Refractive Index @ 20°C.</th>
<th>Density @ 20°C.</th>
<th>g/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Formamide</td>
<td>2-3</td>
<td>210</td>
<td>1.447</td>
<td>1.134</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>N-Methyl Formamide</td>
<td>4</td>
<td>198-199</td>
<td>1.432</td>
<td>1.001</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>N,N-Di Methyl Formamide</td>
<td>-61</td>
<td>153</td>
<td>1.431</td>
<td>0.945</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Acetamide</td>
<td>79-91</td>
<td>221</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>N-Methyl Acetamide</td>
<td>26-28</td>
<td>204-206</td>
<td>1.433</td>
<td>0.957</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>N,N-Di Methyl Acetamide</td>
<td>-20</td>
<td>164.5-166</td>
<td>1.438</td>
<td>0.937</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Propionamide</td>
<td>80-83</td>
<td>213</td>
<td>—</td>
<td>1.042</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>N-Methyl Propionamide</td>
<td>-43</td>
<td>79</td>
<td>1.377</td>
<td>0.915</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>N,N-Di Methyl Propionamide</td>
<td>-45</td>
<td>174-175</td>
<td>1.440</td>
<td>0.920</td>
<td></td>
</tr>
</tbody>
</table>

The extraction of the present invention is conducted by contacting the lube oil distillate with a selective solvent, NMP. Since the feed stock contains aromatic material usually ranging from at least 25 wt %, preferably from 25 wt % to 80 wt % and more preferably from 30 wt % to 60 wt %, the feed stock is initially subjected to an extraction step. Extraction process utilizes a solvent, which is selective for aromatic material, such as a mixture of NMP and at least one co-solvent, and removes the aromatic material, which contributes to poor stability and viscosity index. Removal of aromatic material improves the viscosity index, colour, oxidative stability, thermal stability and inhibition resistance of the base oil. The solvent extraction is conducted with hydrocarbon oil to solvent mixture in the weight ratio in the range of from about 1:0.8 to 1:2,5, more preferably in the range from about 1:1.2 to 1:1.8, depending on the feed stock. The operating conditions for NMP extraction cover a temperature range of about 25°C to 250°C., more preferably from 50 to 200°C.

Generally, the co-solvent is added in an amount less than about 60 weight % based on total solvent mixture, less than about 50 wt % based on total solvent mixture, less than about 40 wt % based on total solvent mixture; less than about 30 wt % based on total solvent mixture, less than about 20 wt % based on total solvent mixture; depending on the feedstock.

For example, a 30 wt % co-solvent, 0.75 wt % water and NMP blend as solvent mixture is used in the extraction process of the present invention when the feedstock is Arab Mix Inter-Neutral distillate. For example, in the solvent mixture comprising NMP and co-solvent (without water), 50 wt % co-solvent and 50 wt % NMP blend is used in the extraction process of the present invention when the feedstock is Arab Mix Inter-neutral distillate. Co-solvents used in the process of the present invention have a boiling point in the range of from about 70°C. to 225°C., preferably in the range of from about 140°C. to 200°C. Use of co-solvents in NMP extraction
process increases the raffinate yield at the same raffinate refractive index (RI) compared to NMP-water system at the same operating condition.

Advantages

0059 The previously described versions of the subject matter and its equivalent thereof have many advantages, including those which are described below.

0060 The advantage of the present invention allows for retrofitting existing equipments. Another advantage of the present invention is use of solvent mixture comprising NMP and at least one co-solvent with water or without water which lowers operating cost as the cost of the co-solvent employed is lower than that of neat NMP. Another additional advantage of using solvent mixture is that it produces same quality raffinate as those of neat NMP-water measured by the refractive index but produces higher yield of raffinate at same feed to solvent mixture ratio. Yet another advantage of using solvent mixture is the flexibility in extraction of various feedstocks. It can be employed for lighter lube distillate namely, spindle oil extraction to heavier oil namely, deasphalted oil extraction.

EXAMPLES

0061 The disclosure will now be illustrated with working examples, which is intended to illustrate the working of disclosure and not intended to take restrictively to imply any limitations on the scope of the present disclosure.

Example 1

0062 Liquid-liquid equilibrium (LLE) batch extraction was performed using NMP and water as the solvent mixture in lab scale jacketed glass extraction apparatus batch. The feed, Arab Mix Inter neutral (IN) distillate was preheated. 150 gm of feed, whose properties are given in Table 2, and 180 gm of solvent mixture were fed into the extraction apparatus. The temperature of the equilibrium setup is kept at 70°C. The feed and solvent were mixed well using a stirrer. The stirrer speed was kept constant throughout the 90 minutes of mixing time. After mixing the content, it was kept for 3 hours to settle i.e. allow complete phase separation. After the settling of phases, the extract and raffinate phases were separated accurately and collected separately. The raffinate and extract phases were weighed accurately with precision balance to ensure material balance. The solvent was stripped both from the extract and raffinate with nitrogen under vacuum. The stripped raffinate and extract phases were weighed and the raffinate yield was obtained based on the feed. Final raffinate samples were analyzed for refractive index.

<table>
<thead>
<tr>
<th>Solvent system</th>
<th>Co-solvent</th>
<th>Raffinate Composition (wt %)</th>
<th>Yield (wt %)</th>
<th>RI @ 50°C C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMP + 1.5% Water</td>
<td>0</td>
<td>64.7</td>
<td>1.49680</td>
<td></td>
</tr>
<tr>
<td>NMP + Co-solvent + 0.75% Water</td>
<td>20</td>
<td>66</td>
<td>1.49624</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>68.6</td>
<td>1.49664</td>
<td></td>
</tr>
</tbody>
</table>

0065 Commercially, lube extraction units are operated to a Refractive Index (RI) specification since for a particular lube crude and type of refining process, raffinate RI correlates with the viscosity index (VI) of the de-waxed oil (DWO), with lower RI corresponding to higher VI.

0066 Analysis of the data in Table 3 shows that for extraction conducted at feed to solvent mixture weight ratio of 1:1.2, the NMP, water and 30 wt % co-solvent mixture was more effective than NMP and water alone, resulting in more than 3 wt % improvement in raffinate yield at the same raffinate RI.

Example 3

0067 LLE extraction was performed in batch extraction apparatus using NMP and water as the solvent mixture. The feed, Arab Mix Heavy Neutral (HN) distillate, properties of which are shown in Table 4, was preheated. 150 gm of feed and 225 gm of solvent mixture were fed in to the extraction setup. The temperature of the content was kept at 80°C. The feed and solvent were mixed with the help of a stirrer. The stirrer speed was kept constant throughout the 90 minutes of mixing period. After mixing, the content was kept for 3 hours to allow complete settling. After the settling of phases, the extract and raffinate phase were collected separately. The raffinate and the extract phase were weighed accurately with precision balance to ensure material balance. The solvent was stripped from the extract and raffinate with nitrogen purging under vacuum. The stripped raffinate and extract phases were weighed and the raffinate yield was determined. Final raffinate samples were analyzed for refractive index.

<table>
<thead>
<tr>
<th>Solvent system</th>
<th>Co-solvent</th>
<th>Raffinate Composition (wt %)</th>
<th>Yield (wt %)</th>
<th>RI @ 50°C C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMP + 1.5% Water</td>
<td>0</td>
<td>64.7</td>
<td>1.49680</td>
<td></td>
</tr>
<tr>
<td>NMP + Co-solvent + 0.75% Water</td>
<td>20</td>
<td>66</td>
<td>1.49624</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>68.6</td>
<td>1.49664</td>
<td></td>
</tr>
</tbody>
</table>
Example 4

The same experiment as in example 3 was performed with NMP, water and at least one co-solvent as the solvent mixture.

The results from the LLE studies of Heavy neutral Distillate of example 3 and example 4 are shown in the Table 5.

<table>
<thead>
<tr>
<th>Solvent system</th>
<th>Co-solvent Composition (wt %)</th>
<th>Raffinate yield (wt %)</th>
<th>RI @ 50° C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMP + 1% Water</td>
<td>0</td>
<td>65.0</td>
<td>1.50222</td>
</tr>
<tr>
<td>NMP + Co-solvent + 0.5% Water</td>
<td>30</td>
<td>67.3</td>
<td>1.50256</td>
</tr>
<tr>
<td>Water</td>
<td>30</td>
<td>67.0</td>
<td>1.50203</td>
</tr>
<tr>
<td>NMP + Co-solvent + 0.3% Water</td>
<td>30</td>
<td>67.0</td>
<td>1.50203</td>
</tr>
</tbody>
</table>

Example 5

The same experiment as in example 4 was performed with NMP, water and at least one co-solvent as the solvent mixture.

The results from the LLE Extraction of Heavy neutral Distillate of example 7 and example 8 are shown below in Table 7.

<table>
<thead>
<tr>
<th>Solvent system</th>
<th>Co-solvent Composition (wt %)</th>
<th>Raffinate yield (wt %)</th>
<th>RI @ 50° C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMP + 1% Water</td>
<td>0</td>
<td>65</td>
<td>1.50223</td>
</tr>
<tr>
<td>NMP + Co-solvent</td>
<td>40</td>
<td>65</td>
<td>1.50144</td>
</tr>
<tr>
<td>(without water)</td>
<td>50</td>
<td>65</td>
<td>1.50228</td>
</tr>
</tbody>
</table>

Example 6

The same experiment as in example 5 was performed with NMP, water and at least one co-solvent as the solvent mixture.

Example 7

The same experiment as in example 6 was performed with NMP, water and at least one co-solvent as the solvent mixture.

Example 8

The same experiment as in example 7 was performed with NMP, water and at least one co-solvent as the solvent mixture.

Example 9

Continuous counter current extraction was performed in 4 meter height extraction column using NMP and water as solvent mixture. The feed, Arab Mix Distillate of Heavy Neutral (HN) distillate was preheated. 150 gm of feed and 225 gm of solvent mixture were fed into the extraction setup. The temperature of the column was kept at 80°C. The experimental procedure was same as in Example 3. Final raffinate samples were analyzed for refractive index.

Example 10

The interface position between the lighter raffinate phase and heavier extract phase was maintained constant. After steady state, i.e. after about 12 to 16 hrs, indicated by constant interface level and constant raffinate and extract phase flows, the raffinate phase and the extract phase were collected simultaneously for a given period of time, i.e. about 30 to 40 minutes. The two phases collected were weighed to ensure material balance. The solvent was stripped from the extract and raffinate with nitrogen under vacuum. The stripped raffinate and extract phases were weighed and the
raffinate yield was obtained. Final raffinate samples were analyzed for density and refractive index (RI).

Example 10

The same experiment as in example 9 was performed with NMP, water and at least one co-solvent as the solvent mixture.

The results from the continuous counter current extraction of example 9 and example 10 are shown in Table 8.

### TABLE 8

<table>
<thead>
<tr>
<th>Properties</th>
<th>NMP + Water</th>
<th>NMP + Water + Co-solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column Top Temperature (°C)</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Column Bottom</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>1.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Solvent to Feed Ratio (w/w)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raffinate Yield (wt %)</td>
<td>65.5</td>
<td>63.5</td>
</tr>
<tr>
<td>Raffinate R.Ig/50°C</td>
<td>1.4844</td>
<td>1.4825</td>
</tr>
</tbody>
</table>

Analysis of the data in Table 8 shows that for extraction conducted at feed to solvent mixture weight ratio 1:1.8, the NMP, water and at least one co-solvent mixture are more effective than NMP water alone, resulting in more than 6 wt % improvement in raffinate yield at same raffinate RI.

Although the subject matter has been described in considerable detail with reference to certain preferred embodiments thereof, other embodiments are possible. As such, the spirit and scope of the appended claims should not be limited to the description of the preferred embodiment contained therein.

What is claimed is:

1. A process for extraction of aromatic material from hydrocarbon oil, said process comprising:
   - contacting the hydrocarbon oil with a solvent mixture to obtain an extract phase and a raffinate product phase, wherein the solvent mixture comprises N-Methyl-2-Pyrrolidone (NMP) and at least one co-solvent capable of facilitating phase separation and separating the extract phase from the raffinate product phase, wherein the extract phase contains the aromatic material.
   - The process as claimed in claim 1, further comprising:
     - obtaining the raffinate from the raffinate product phase by removing the solvent from the raffinate phase.
   - The process as claimed in claim 1, wherein the hydrocarbon oil is a lube oil distillate.
   - The process as claimed in claim 1, wherein the hydrocarbon oil has a boiling point in the range of 150°C to 600°C.
   - The process as claimed in claim 1, wherein the co-solvent is a N,N-dimethyl amide.
   - The process as claimed in claim 1, wherein the co-solvent is selected from the group consisting of formamide, N-methyl formamide, N,N-dimethyl formamide, acetamide, N-methyl acetamide, N,N-dimethyl acetamide, Propionamide, N-methyl propionamide and N,N-dimethyl propionamide or mixtures thereof.
   - The process as claimed in claim 1, wherein the ratio of NMP and co-solvent in the solvent mixture is in the range of 40:60 (w/w) to 90:10 (w/w).
   - The process as claimed in claim 1, wherein the hydrocarbon oil and the solvent mixture are in the weight ratio in the range of 1:0.8 to 1:2.5.
   - The process as claimed in claim 1, wherein the process is either a continuous counter current extraction process or a batch extraction process.
   - The process as claimed in claim 1, wherein the solvent mixture is recovered and reused in the process.
   - A process for extraction of aromatic material from hydrocarbon oil, said process comprising:
     - contacting the hydrocarbon oil with a solvent mixture to obtain an extract phase and a raffinate product phase, wherein the solvent mixture comprises N-Methyl-2-Pyrrolidone (NMP), water and at least one co-solvent capable of facilitating phase separation and separating the extract phase from the raffinate product phase, wherein the extract phase contains the aromatic material.
     - The process as claimed in claim 11, further comprising:
       - obtaining the raffinate from the raffinate product phase by removing the solvent from the raffinate phase.
     - The process as claimed in claim 11, wherein the hydrocarbon oil is a lube oil distillate.
     - The process as claimed in claim 11, wherein the hydrocarbon oil has a boiling point in the range of 150°C to 600°C.
     - The process as claimed in claim 11, wherein the co-solvent is a N,N-dimethyl amide.
     - The process as claimed in claim 11, wherein the co-solvent is selected from the group consisting of formamide, N-methyl formamide, N,N-dimethyl formamide, acetamide, N-methyl acetamide, N,N-dimethyl acetamide, Propionamide, N-methyl propionamide and N,N-dimethyl propionamide or mixtures thereof.