

DESCRIPTION

Title of Invention

RUBBER COMPOUNDING OIL AND METHOD FOR PRODUCING SAME

5 Technical Field

[0001] The present invention relates to a rubber compounding oil and to a method for producing the same.

Background Art

10 [0002] High-aromatic mineral oils have high affinity for rubber components, excellent processability and softening properties as rubber compositions, and excellent economy, and they are therefore used for production of rubber compositions comprising natural rubber, synthetic rubber and the like. For example, extender oils are added to synthetic rubber including SBR during their synthesis, while process oils are added to rubber processed products such as tires to improve their processability or the quality of the rubber processed products (Patent document 1, for example).

20 [0003] In Patent document 1 there is proposed the use of a petroleum-based process oil having an aromatic hydrocarbon content (C_A) of 20-35 mass%, a glass transition temperature T_g of between -55°C and -30°C , a dynamic viscosity (100°C) of $20\text{-}50\text{ mm}^2/\text{s}$ and a polycyclic aromatic component content (PCA) of no greater than 3 mass% in the petroleum-based process oil. When a rubber obtained by adding such a petroleum-based process oil to diene rubber is used in a tire, it is possible to achieve both low fuel consumption and grip properties, and to increase the thermal aging resistance or heat-resistant wearability.

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[0004] Known rubber compounding oils include high aromatic base oils such as vacuum distillation residue, deasphalted oil, or solvent extracts of deasphalted oil or lubrication fractions (Patent document 2, for example). However, when such high aromatic base oils are modified for a high flash point from the viewpoint of safety, or to avoid falling within the definition of Level-4 Hazardous Petroleum according to the Japanese Fire Service Law, this results in high viscosity, while also increasing the pour point and lowering the manageability for storage, transport and handling. It has therefore been proposed to subject high aromatic base oils to dewaxing treatment to lower the pour point, but this complicates the production process and notably reduces economy. A demand therefore exists for a rubber compounding oil requiring no such complex production steps, and having high viscosity and a high flash point, as well as a low pour point.

[0005] In Europe, restrictions prohibiting the use of substances containing more than minimum amounts of DMSO extracts or indicated carcinogenic polycyclic aromatic compounds in the production of tires or tire parts have been enacted since 2010, and a demand exists for rubber compounding oils that meet these restrictions.

[Citation List]

[Patent literature]

[0006] [Patent document 1] Japanese Unexamined Patent Application Publication No. 2004-155959

[Patent document 2] Japanese Patent Publication No. 3658155

Summary of Invention

Technical Problem

[0007] The present invention has been accomplished in light of these circumstances, and its object is to provide a rubber compounding oil having a high flash point and high aromaticity, with an adequately reduced content of the indicated carcinogenic polycyclic aromatic compounds, a low pour point, and excellent economy, as well as a method for producing it.

Solution to Problem

[0008] As a result of much diligent research on base materials for rubber compounding oils, the present inventors have found that by using a specific extract and a specific lubricant base oil, it is possible to obtain a low pour point rubber compounding oil having high viscosity, a high flash point and high aromaticity, while also having an adequately reduced content of indicated carcinogenic polycyclic aromatic compounds (hereunder, "indicated aromatic compounds"), as well as excellent economy, and the invention has been completed upon this finding.

[0009] Specifically, the invention provides a rubber compounding oil comprising an extract (A) and a lubricant base oil (B) wherein the extract (A) has an aniline point of 40-90°C, a %C_A of 25-45 and a %C_N of 5-20 according to ASTM D3238, a nitrogen content of 0.01 mass% or greater, a pour point of no higher than +30°C, a benzo(a)pyrene content of no greater than 1 ppm by mass, a total content of indicated aromatic compounds of no greater than 10 ppm by mass, and a 40°C dynamic viscosity of 650 mm²/s or greater, and the lubricant base oil (B) has a pour point of no higher than -10°C, an aniline point of 70°C or higher, a %C_A of 3-20 and a %C_N of 15-35 according to ASTM D3238,

a nitrogen content of no greater than 0.01 mass%, a 90% point of 500°C or higher in GC distillation, a flash point of 250°C or higher, a benzo(a)pyrene content of no greater than 1 ppm by mass and a total content of indicated aromatic compounds of no greater than 10 ppm by mass.

[0010] According to the invention, adding a specific extract (A) and lubricant base oil (B) can produce a rubber compounding oil having a high flash point and high aromaticity, a sufficiently reduced content of indicated aromatic compounds, and also a low pour point. Furthermore, since it allows production without complicated production steps, the economy is also excellent.

[0011] Preferably, the rubber compounding oil of the invention has a flash point of 250°C or higher, an aniline point of no higher than 90°C, a 40°C dynamic viscosity of 200 mm²/s or greater, a pour point of no higher than +30°C, a benzo(a)pyrene (BaP) content of no greater than 1 ppm by mass and a total content of the aforementioned indicated aromatic compounds of no greater than 10 ppm by mass. In order to obtain satisfactory low fuel consumption, grip properties and thermal aging resistance for production of a diene rubber composition, as described in Patent document 1, the rubber compounding oil of the invention most preferably has a %C_A of 20-35, a glass transition temperature T_g of between -55°C and -30°C and a dynamic viscosity (100°C) of 20-50 mm²/s, as well as a benzo(a)pyrene (BaP) content of no greater than 1 ppm by mass, a total content of indicated aromatic compounds of preferably no greater than 10 ppm by mass, and a pour point of no higher than +20°C and especially no higher than +15°C.

[0012] In the rubber compounding oil of the invention, the extract (A) is preferably an extract obtained by extraction by contacting a polar solvent with deasphalted oil obtained by deasphalting of a vacuum distillation residue oil of atmospheric distillation residue oil from crude oil, in one or two stages.

[0013] Preferably in the rubber compounding oil of the invention, the extract (A) includes an extract obtained by a two-stage polar solvent extraction step, the extract being obtained by contacting a polar solvent with a raffinate obtained by contacting a polar solvent with a vacuum distillation fraction of atmospheric distillation residue oil from crude oil in a first extraction column having a bottom temperature of 30-90°C and a top temperature that is higher than the bottom temperature, in a second extraction column having a bottom temperature and top temperature that are at least 10°C higher than those of the first extraction column, wherein the extract has a 15°C density of 0.94 g/cm³ or greater and a total aromatic content of 30 mass% or greater according to ASTM D2549.

[0014] Also in the rubber compounding oil of the invention, preferably the lubricant base oil (B) comprises a dewaxing oil (c) of a first raffinate obtained by a one-stage polar solvent extraction step and/or a dewaxing oil (d) of a second raffinate obtained by a two-stage polar solvent extraction step, the dewaxing oil (c) being obtained by refining treatment including a dewaxing step on a first raffinate obtained by contacting a polar solvent with a vacuum distillation fraction of an atmospheric distillation residue oil from a crude oil in a first extraction column having a bottom temperature of 30-90°C and a top temperature

that is higher than the bottom temperature, and the dewaxing oil (d) being obtained by refining treatment including a dewaxing step on a second raffinate obtained by contacting a polar solvent with the first raffinate, in a second extraction column having a bottom temperature and a top temperature that are at least 10°C higher than those of the first extraction column.

[0015] According to the invention there is also provided a method for producing a rubber compounding oil comprising a step of mixing an extract (A) having an aniline point of 40-90°C, a %C_A of 25-45 and a %C_N of 5-25 according to ASTM D3238, a nitrogen content of 0.01 mass% or greater, a pour point of no higher than +30°C, a benzo(a)pyrene content of no greater than 1 ppm by mass, a total content of indicated aromatic compounds of no greater than 10 ppm by mass, and a 40°C dynamic viscosity of 650 mm²/s or greater, with a lubricant base oil (B) having a pour point of no higher than -10°C, an aniline point of 70°C or higher, a %C_A of 3-20 and a %C_N of 15-35 according to ASTM D3238, a nitrogen content of no greater than 0.01 mass%, a 90% point of 500°C or higher in GC distillation, a flash point of 250°C or higher, a benzo(a)pyrene content of no greater than 1 ppm by mass and a total content of indicated aromatic compounds of no greater than 10 ppm by mass.

[0016] According to the production method of the invention, adding a specific extract (A) and lubricant base oil (B) can produce a rubber compounding oil having a high flash point and high aromaticity, a sufficiently reduced content of indicated aromatic compounds, and also a low pour point. The production method of the invention also allows

production without complicated production steps, and is therefore highly economical.

Effects of the Invention

5 [0017] According to the invention it is possible to provide a rubber compounding oil having a high flash point and high aromaticity, with an adequately reduced content of indicated aromatic compounds, a low pour point, and excellent economy, as well as a method for producing it.

Brief Description of the Drawings

10 [0018] Fig. 1 is a process schematic diagram showing an example of a method for producing a base material to be used in a rubber compounding oil of the invention.

Fig. 2 is a process schematic diagram showing another example of a method for producing a base material to be used in a rubber compounding oil of the invention.

15 Fig. 3 is a process schematic diagram showing yet another example of a method for producing a base material to be used in a rubber compounding oil of the invention.

Description of the Embodiments

20 [0019] Preferred embodiments of the invention will now be explained with reference to the accompanying drawings where necessary. Identical or corresponding elements are indicated by like reference numerals and their explanation will not be repeated in some cases.

[0020] The rubber compounding oil of this embodiment is a rubber compounding oil comprising an extract (A) having specific properties (hereunder referred to simply as "component (A)") and a lubricant base oil (B) having specific properties (hereunder referred to simply as

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"component (B)").

[0021] Component (A) is an extract having an aniline point of 40-90°C, a %C_A of 25-45 and a %C_N of 5-20 according to ASTM D3238, a nitrogen content of 0.01 mass% or greater, a pour point of no higher than +30°C, a benzo(a)pyrene content of no greater than 1 ppm by mass, a total of indicated aromatic compounds of no greater than 10 ppm by mass, and a 40°C dynamic viscosity of 650 mm²/s or greater.

[0022] The extract used as component (A) may be an extract obtained from a polar solvent extraction step, or a product of refining treatment of the extract, so long as it satisfies the aforementioned conditions. The refining treatment referred to here may be dewaxing, hydrocracking, hydrorefining, distillation or the like. From the viewpoint of production cost and more suitable properties as a rubber compounding oil, component (A) is preferably the direct extract obtained from a polar solvent extraction step, without refining treatment. The reasons for this include that a rubber compounding oil with excellent low-temperature performance can be obtained without dewaxing treatment, that hydrocracking will tend to lower the aromaticity, and that refining treatment will complicate the production process.

[0023] The aniline point of component (A) is 40-90°C, preferably 45-70°C and more preferably 50-65°C. If the aniline point is within this range, it will be easy to produce a rubber compounding oil with excellent compatibility with rubber and with a suitable aniline point for maintaining the properties of the rubber composition, even if it contains a lubricant base oil with a high aniline point as component (B). The "aniline point" as used herein is the aniline point measured according to

JIS K 2256-1985.

[0024] In regard to the composition of component (A), $\%C_A$ is 25-45 and preferably 30-40, and $\%C_N$ is 5-20 and preferably 6-12. The $\%C_P$ value is determined according to $\%C_A$ and $\%C_N$, and it is preferably 35-70 and more preferably 48-64. If the composition of component (A) is within this range, it will be easy to produce a rubber compounding oil having excellent compatibility with rubber and having a suitable composition for maintaining the properties of the rubber composition, even if it contains a lubricant base oil with high paraffinicity as component (B). The $\%C_P$, $\%C_N$ and $\%C_A$ referred to here are, respectively, the percentage of paraffinic carbons with respect to total carbon atoms, the percentage of naphthenic carbons with respect to total carbons and the percentage of aromatic carbons with respect to total carbons, as determined by the method of ASTM D 3238-85 (n-d-M ring analysis).

[0025] The nitrogen content of component (A) is 0.01 mass% or greater, preferably 0.05 mass% or greater, even more preferably 0.1 mass% or greater and most preferably 0.15 mass% or greater. A high nitrogen content of component (A) results in a lower nitrogen content of the raffinate by-product of polar solvent extraction, and higher refining efficiency of the lubricant base oil, and therefore using component (A) with a high nitrogen content as the rubber compounding oil is preferred from the viewpoint of economy. The nitrogen content for the purpose of the invention is the nitrogen content by chemiluminescence, measured according to JIS K2609.

[0026] The pour point of component (A) is no higher than +30°C and

preferably between +5 and +25°C, while from the viewpoint of further lowering the pour point of the rubber compounding oil, it is more preferably between +5 and +20°C, and most preferably between +7.5 and +15°C.

5 [0027] The rubber compounding oil of this embodiment comprises component (B) as described hereunder, and it therefore has an adequately low pour point even if it contains an unrefined component (A) with a high pour point. The "pour point", as used herein, is the pour point measured according to JIS K2269.

10 [0028] Component (A) has a sufficiently reduced content of the following 8 aromatic compounds (hereunder referred to collectively as "indicated aromatic compounds").

[0029] 1) Benzo(a)pyrene (BaP)

2) Benzo(e)pyrene (BeP)

15 3) Benzo(a)anthracene (BaA)

4) Chrysene (CHR)

5) Benzo(b)fluoranthene (BbFA)

6) Benzo(j)fluoranthene (BjFA)

7) Benzo(k)fluoranthene (BkFA)

20 8) Dibenzo(a, h)anthracene (DBAhA)

[0030] "Benzo(a)pyrene", as used herein, is the benzo(a)pyrene (BaP) listed as 1) above, and an "indicated aromatic compound" is any of the aromatic compounds (PAH) listed as 1)-8) above.

[0031] The content of benzo(a)pyrene (BaP) of 1) in component (A) is
25 no greater than 1 ppm by mass, and the total content of indicated aromatic compounds of 1)-8) above is no greater than 10 ppm by mass.

This will yield a more highly safe rubber compounding oil with no concerns of carcinogenicity. These indicated aromatic compounds can be quantitatively analyzed by GC-MS analysis, after separation and concentration of the components of interest, upon preparing a sample containing an added internal standard substance.

[0032] The 40°C dynamic viscosity of component (A) is 650 mm²/s or greater, preferably 800 mm²/s or greater, more preferably 2000 mm²/s or greater and even more preferably 5000 mm²/s or greater, and preferably no greater than 20,000 mm²/s and more preferably no greater than 10,000 mm²/s.

[0033] If the 40°C dynamic viscosity of component (A) is less than 650 mm²/s, it may not be possible to obtain a sufficiently low pour point even with the presence of component (B). If the 40°C dynamic viscosity of component (A) is 700 mm²/s or greater and preferably 800 mm²/s or greater, it will be easier to obtain a pour point of no higher than 15°C for the rubber compounding oil. In this case, the pour point of component (A) is preferably between +5 and +20°C, and more preferably between +7.5 and +15°C.

[0034] With this embodiment it is possible to obtain a rubber compounding oil with a low pour point by adding component (A), having a 40°C dynamic viscosity of 650 mm²/s or greater and preferably a pour point of between +5 and +20°C, and component (B). If the dynamic viscosity of component (A) exceeds 20,000 mm²/s, it will tend to be difficult to obtain a rubber compounding oil having suitable dynamic viscosity as a rubber compounding oil (a 100°C dynamic viscosity of 10-70 mm²/s, preferably 15-50 mm²/s and most preferably

20-32 mm²/s). The dynamic viscosity at each temperature, as used herein, is the dynamic viscosity at each temperature measured according to JIS K2283.

5 [0035] The asphaltene content of component (A) is preferably no greater than 3 mass%, more preferably no greater than 1 mass%, even more preferably no greater than 0.5 mass% and most preferably no greater than 0.1 mass%. The "asphaltene content", as used herein, is the asphaltene content measured according to IP-143.

10 [0036] From the viewpoint of the flash point of the rubber compounding oil in terms of safety and of not falling within the definition of Level-4 Hazardous Petroleum according to the Japanese Fire Service Law, which specifies a point of 250°C or higher, the flash point of component (A) is preferably 250°C or higher, more preferably 270°C or higher, even more preferably 290°C or higher and most
15 preferably 300°C or higher. The "flash point", as used herein, is the flash point based on Cleveland open-cup (COC), measured according to JIS K2265.

20 [0037] The total aromatic content of component (A) is preferably 50 mass% or greater, more preferably 55 mass% or greater, even more preferably 60 mass% or greater and most preferably 65 mass% or greater. The total aromatic content of component (A) is also preferably no greater than 90 mass%, more preferably no greater than 80 mass% and even more preferably no greater than 75 mass%. If the total aromatic content of component (B) is less than 50 mass%, it will tend to
25 be difficult to obtain a rubber compounding oil with high aromaticity, and if the total aromatic content is greater than 90 mass% the yield in

the polar solvent extraction step will tend to be reduced and production cost increased. The "total aromatic content", as used herein, is the content of the aromatic fraction measured according to ASTM D 2549.

[0038] Component (B) that is included in the rubber compounding oil of this embodiment is a lubricant base oil having a pour point of no higher than -10°C , an aniline point of 70°C or higher, a $\%C_A$ of 3-20 and a $\%C_N$ of 15-35 by n-d-M analysis, a nitrogen content of no greater than 0.01 mass%, a 90% point of 500°C or higher according to GC distillation, a flash point of 250°C or higher, a benzo(a)pyrene content of no greater than 1 ppm by mass and a total of indicated aromatic compounds of no greater than 10 ppm by mass.

[0039] The pour point of component (B) is no higher than -10°C , and it may be below -20°C . From the viewpoint of maintaining a low pour point of the rubber compounding oil and reducing production cost, it is preferably between -10 and -20°C . By using component (B) having a pour point of no higher than -10°C , it is possible to obtain a rubber compounding oil with a low pour point.

[0040] The aniline point of component (B) is 70°C or higher, preferably 90°C or higher and more preferably 100°C or higher. From the viewpoint of facilitating production of a rubber compounding oil having a suitable aniline point for excellent compatibility with rubber and to maintain the properties of the rubber composition, it is preferably no higher than 120°C .

[0041] In regard to the composition of component (B), $\%C_A$ is 3-20 and preferably 5-10, and $\%C_N$ is 15-35 and preferably 20-30. The $\%C_P$ value is determined according to $\%C_A$ and $\%C_N$, and it is preferably 45-

82, more preferably 60-75 and even more preferably 65-70. By using component (B) having a composition within this range, it will be easy to produce a rubber compounding oil having excellent compatibility with rubber and having a suitable composition for maintaining the properties of the rubber composition.

[0042] The nitrogen content of component (B) is no greater than 0.01 mass% and preferably no greater than 0.008 mass%. The nitrogen content of component (B) may be less than 0.001 mass%, but from the viewpoint of reducing production cost for the rubber compounding oil by use of a lubricant base oil of low purity, it is preferably 0.002 mass% or greater and more preferably 0.003 mass% or greater.

[0043] The flash point of component (B) is 250°C or higher and preferably 255°C or higher, for a rubber compounding oil flash point of 250°C or higher, from the viewpoint of not falling within the definition of a level-4 hazardous petroleum material. Because the flash point of component (A) is high, the flash point of component (B) does not need to be higher than necessary, and it is preferably no higher than 290°C and more preferably no higher than 280°C.

[0044] The 90% point of component (B) in GC distillation is 500°C or higher and preferably 500-600°C. For this embodiment, the 90% point of component (B) in GC distillation is preferably 510-550°C. According to another embodiment, the 90% point of component (B) in GC distillation is preferably 550-590°C. There are no particular restrictions on the 10% point of component (B) in GC distillation, but it is preferably 400-510°C and more preferably 440-500°C, from the viewpoint of safety in terms of the flash point of the rubber

compounding oil, or to avoid falling within the definition of Level-4 Hazardous Petroleum material according to the Japan Fire Service Law which specifies a point of 250°C or higher. According to one mode, it may be 440-470°C, while according to another mode it may be 450-500°C.

[0045] The content of benzo(a)pyrene (BaP) of 1) above in component (B) is no greater than 1 ppm by mass, and the total content of indicated aromatic compounds mentioned above is no greater than 10 ppm by mass. This will yield a highly safe rubber compounding oil with low carcinogenicity.

[0046] The 40°C dynamic viscosity of component (B) is preferably 50-500 mm²/s, more preferably 60-300 mm²/s and even more preferably 70-200 mm²/s. When component (A) having a 40°C dynamic viscosity of 2000 mm²/s or greater is used for this embodiment, the 40°C dynamic viscosity of the component (B) that is used is preferably 50-150 mm²/s and more preferably 80-120 mm²/s in order to obtain a rubber compounding oil with a suitable dynamic viscosity. When component (A) has a 40°C dynamic viscosity of less than 2000 mm²/s, as a different embodiment, the 40°C dynamic viscosity of the component (B) that is used is preferably 50-500 mm²/s and more preferably 60-80 mm²/s and/or 120-250 mm²/s, in order to obtain a rubber compounding oil with suitable dynamic viscosity.

[0047] The total aromatic content of component (B) is preferably 20 mass% or greater, more preferably 30 mass% or greater and even more preferably 35 mass% or greater. The total aromatic content of component (B) is also preferably no greater than 50 mass% and more

preferably no greater than 45 mass%. If the total aromatic content of component (B) is less than 20 mass%, a rubber compounding oil with high aromaticity may not be obtainable. If the total aromatic content exceeds 50 mass%, on the other hand, the oxidation stability of component (B) used as a lubricant base oil will be notably impaired and it will less easily serve as both a lubricant base oil and for a rubber compounding oil, while the economy of the petroleum refining process as a whole will tend to be reduced.

[0048] The rubber compounding oil of this embodiment can be obtained by combining component (A) and component (B) described above. The rubber compounding oil of this embodiment may also comprise a base material other than component (A) and a base material other than component (B), so long as the effect of the invention is not significantly impeded.

[0049] The rubber compounding oil of this embodiment preferably has affinity for rubber, softening properties, a high flash point, safety and satisfactory handling, as well as the following properties in order to obtain satisfactory low fuel consumption, grip properties and thermal aging resistance when a rubber composition is produced.

· 15°C Density: Generally 0.9 g/cm³-1.0 g/cm³, preferably 0.94 g/cm³ or greater, more preferably 0.945 g/cm³ or greater, and preferably no greater than 0.98 g/cm³ and more preferably no greater than 0.96 g/cm³.

· Flash point: Generally 250-350°C, preferably 260°C or higher, more preferably 280°C or higher, and preferably no higher than 320°C and even more preferably no higher than 310°C.

· 40°C Dynamic viscosity: Generally 200-3000 mm²/s, preferably 300

mm²/s or greater, more preferably 400 mm²/s, even more preferably 500 mm²/s or greater, and preferably no greater than 2000 mm²/s, more preferably no greater than 1000 mm²/s and even more preferably no greater than 800 mm²/s.

5 · 100°C Dynamic viscosity: Generally 10-100 mm²/s, preferably 15 mm²/s or greater, more preferably 20 mm²/s or greater, and preferably no greater than 60 mm²/s, more preferably no greater than 50 mm²/s, even more preferably no greater than 32 mm²/s.

10 · Aniline point: Generally 50-100°C, preferably 60°C or higher, more preferably 65°C or higher, even more preferably 70°C or higher, and preferably no higher than 90°C and more preferably no higher than 85°C.

15 · Nitrogen content: Generally 0.01-0.2 mass%, preferably 0.03 mass% or greater, even more preferably 0.05 mass% or greater, and preferably no greater than 0.15 mass% and more preferably no greater than 0.1 mass%.

· %C_N: Generally 5-30, preferably 10 or greater, more preferably 14 or greater, and preferably no greater than 25 and more preferably no greater than 20.

20 · %C_A: Generally 10-40, preferably 17 or greater, more preferably 20 or greater, and preferably no greater than 35, more preferably no greater than 30 and even more preferably no greater than 25.

25 · %C_P: Generally 30-85, preferably 40 or greater, more preferably 50 or greater, and preferably no greater than 73 and more preferably no greater than 66.

· Total aromatic content (ASTM D2549): Generally 30-90 mass%,

preferably 40 mass% or greater, more preferably 50 mass% or greater, and preferably no greater than 80 mass% and more preferably no greater than 70 mass%.

· Saturated components according to ASTM D2007 (Clay-gel method):

5 Generally 5-50 mass%, preferably 10 mass% or greater, more preferably 20 mass% or greater, and preferably no greater than 40 mass% and more preferably no greater than 30 mass%.

· Aromatic content according to ASTM D2007 (Clay-gel method):

10 Generally 40-90 mass%, preferably 50 mass% or greater, more preferably 55 mass% or greater, even more preferably 57 mass% or greater and most preferably 60 mass% or greater, and preferably no greater than 80 mass% and more preferably no greater than 70 mass%.

· Polar compound content according to ASTM D2007 (Clay-gel

15 method): Generally 1-20 mass%, preferably 2 mass% or greater, more preferably 5 mass% or greater, and preferably no greater than 15 mass%, more preferably no greater than 12 mass% and even more preferably no greater than 10 mass%.

· Saturated component/polar compound ratio according to ASTM

20 D2007 (Clay-gel method): Generally 0.25-50, preferably 1 or greater, more preferably 2.5 or greater and even more preferably 3 or greater, and preferably no greater than 20, more preferably no greater than 10 and even more preferably no greater than 5.

· Benzo(a)pyrene (BaP) content: No greater than 1 ppm by mass.

25 · Total content of indicated aromatic compounds: No greater than 10 ppm by mass.

· Pour point: Between -10°C and +30, preferably -5°C or higher, and

preferably no higher than +15°C, more preferably no higher than +5°C, and even more preferably no higher than 0°C.

- Glass transition point (T_g): Between -60 and -10°C, preferably -55°C or higher, and preferably no higher than -30°C, more preferably no higher than -40°C, even more preferably no higher than -45°C and especially preferably no higher than -48°C.

[0050] The "glass transition point (T_g)" of the aromatic-containing base oil, as used herein, is the glass transition point obtained from the peak of thermal change in the glass transition range, as measured by DSC (differential scanning calorimeter) at a fixed temperature-elevating rate (10°C/min). The initial temperature is usually about 30°C-50°C lower than the anticipated glass transition point, or a lower temperature, and temperature elevation is initiated after maintaining this initial temperature for a prescribed period of time. Specifically, measurement may be conducted under the following conditions for this embodiment.

[0051] Apparatus: DSC Q100 Thermal Analysis System by TA Instruments

Initial temperature: -90°C, maintained for 10 minutes

Temperature-elevating rate: 10°C/min

Final temperature: 50°C, maintained for 10 minutes

[0052] The method of calculating the glass transition point from the peak of thermal change may be the method according to JIS K 7121.

[0053] The rubber compounding oil of this embodiment can be obtained by combining component (A) and component (B). There are no particular restrictions on the content ratios of component (A) and

component (B), and for example, the content ratio of component (A) may be 5-95 mass% and preferably 40-90 mass% based on the total mass of the rubber compounding oil. However, it is preferably 55-85 mass%, since the actual pour point is lower than the pour point predicted from the pour points of the base materials, component (A) and component (B). It is also preferably 40-75 mass% and more preferably 55-75 mass%, from the viewpoint of obtaining a rubber compounding oil with suitable viscosity and a lower pour point.

[0054] Similarly, the mixing proportion of component (B) is 5-95 mass% and preferably 10-60 mass% based on the total mass of the rubber compounding oil. The content ratio is 5-95 mass% and preferably 40-90 mass% based on the total mass of the rubber compounding oil. However, the content ratio of component (B) is preferably 15-45 mass%, since the actual pour point of the rubber compounding oil is lower than the pour point predicted from the pour points of the base materials, component (A) and component (B). It is also preferably 25-60 mass% and more preferably 25-45 mass%, from the viewpoint of obtaining a rubber compounding oil with suitable viscosity and a lower pour point.

[0055] The rubber compounding oil of this embodiment can be obtained by combining component (A) and component (B) in the proportion described above. A method for producing component (A) and component (B) as base materials for a rubber compounding oil will now be explained.

[0056]

[Method for producing component (A)]

The method for producing component (A) is not particularly restricted so long as the properties of component (A) are satisfied, and for example, it may be a method in which the vacuum distillation residue oil of atmospheric distillation residue oil from crude oil is subjected to deasphalting in 1 stage or 2 or more stages, and the obtained deasphalted oil is contacted with a polar solvent and extracted.

[0057] Two different methods for producing component (A) (referred to as "first mode" and "second mode" for convenience) will now be explained in detail with reference to the accompanying drawings.

[0058]

(First mode)

Fig. 1 is a process schematic diagram showing an example of a method for producing component (A). For the first mode, first a deasphalting step is carried out in which the vacuum distillation residue oil is subjected to deasphalting. The deasphalting step may be carried out in 1 stage or in 2 or more stages. However, a deasphalting step with 2 or more stages is preferred from the viewpoint of obtaining two or more different raffinates with different dynamic viscosities that are useful as lubricant base oil starting materials, and extracts with different dynamic viscosities that are suitable as rubber compounding oils, and of increasing the diversity for production of lubricant oil products and rubber compounding oils. From the viewpoint of avoiding complication of the process, however, the deasphalting step preferably has no more than 2 stages. A method of conducting the deasphalting step in 2 stages, a first deasphalting step and a second deasphalting step, will now be explained.

[0059]

(First deasphalting step)

The first deasphalting step is a step in which the vacuum distillation residue oil of atmospheric distillation residue oil from crude oil is contacted with a deasphalting solvent in countercurrent flow in a first deasphalting column 10, for separation into a first deasphalted oil and a first asphalt oil, to obtain a first deasphalted oil and a first asphalt oil. The deasphalting solvent is appropriately recovered using a stripping column or the like (not shown) provided at the downstream end of the first deasphalting column 10, and is circulated for reuse.

[0060] The deasphalting solvent is supplied to the first deasphalting column 10 through tubing 14. The vacuum distillation residue oil is separately supplied to the first deasphalting column 10 through tubing 12. The first deasphalted oil is obtained through tubing 16, and the first asphalt oil is obtained through tubing 18.

[0061] The deasphalting solvent used may be a non-polar light hydrocarbon such as propane or butane, and is preferably propane. For the deasphalting conditions, the 100°C dynamic viscosity of the first deasphalted oil is preferably 10-35 mm²/s, more preferably 15-30 mm²/s and even more preferably 18-28 mm²/s. The deasphalting temperature can be adjusted by varying the top temperature and/or bottom temperature of the first deasphalting column 10. The deasphalting conditions in the first deasphalting step may be, for example, as follows.

[0062]

· Solvent ratio: The volume ratio based on the vacuum distillation residue oil is preferably 1-6, more preferably 1.5-4 and even more

preferably 2-4.

· Top temperature of first deasphalting column 10: This is preferably 60-120°C, more preferably 80-100°C and even more preferably 85-95°C.

· Bottom temperature of first deasphalting column 10: This is preferably 50-100°C, more preferably 60-90°C and even more preferably 70-85°C.

· First deasphalted oil yield: This is preferably 1-30 vol%, more preferably 2-20 vol% and even more preferably 3-15 vol%, based on the vacuum distillation residue oil.

[0063] The first deasphalted oil obtained in this manner is used in the first polar solvent extraction step described hereunder and separated into a first raffinate and a first extract. Also, the first asphalt oil (bottom oil not extracted into the deasphalting solvent: oil with high asphaltene content) may be directly used as asphalt starting material. Also, the first asphalt oil is preferably used directly as asphalt starting material for second asphalt oil obtained by separation of the second deasphalted oil by the second deasphalting step described hereunder.

[0064]

(Second deasphalting step)

The second deasphalting step is a step in which the first asphalt oil and a deasphalting solvent are contacted in countercurrent flow in a second deasphalting column 20, for separation into a second deasphalted oil and a second asphalt oil, to obtain a second deasphalted oil and a second asphalt oil. The deasphalting solvent is appropriately recovered using a stripping column or the like (not shown) provided at the downstream end of the second deasphalting column 20, and is circulated for reuse.

[0065] The deasphalting solvent is supplied to the second deasphalting

column 20 through tubing 24. The first asphalt oil is separately supplied to the second deasphalting column 20 through tubing 18. The second deasphalted oil is obtained through tubing 26, and the second asphalt oil is obtained through tubing 28.

5 [0066] The deasphalting solvent used may be a non-polar light hydrocarbon such as propane or butane, and is preferably propane, as in the first deasphalting step. The deasphalting solvent used in the second deasphalting step may be the same as or different from that used in the first deasphalting step, but more preferably the same deasphalting
10 solvent is used from the viewpoint of simplification of the process.

[0067] The deasphalting conditions for the second deasphalting step are not particularly restricted so long as they are different from the deasphalting conditions in the first deasphalting step. The deasphalting conditions in the second deasphalting step are preferably
15 adjusted, for example, so that the 100°C dynamic viscosity of the second deasphalted oil is 30-60 mm²/s, preferably 35-50 mm²/s and more preferably 36-45 mm²/s. Such conditions may be the following, for example.

[0068]

20 · Solvent ratio: The volume ratio may be, for example, 1-10, preferably 4-8 and more preferably 5-7 based on the first asphalt oil.

· Top temperature of second deasphalting column 20: This is 50-110°C and preferably 60-80°C. It is also preferably 10-30°C and more preferably 15-25°C lower than the first deasphalting top temperature.

25 · Bottom temperature of second deasphalting column 20: This is 40-80°C and preferably 50-60°C.

· Second deasphalted oil yield: This is 15-50 vol%, preferably 20-45 vol% and more preferably 25-40 vol%, based on the first asphalt oil as the starting material for the second deasphalting step.

5 [0069] The solvent ratio in the second deasphalting step is preferably 1.5-10 times, more preferably 2-5 times and even more preferably 2.5-4 times the solvent ratio in the first deasphalting step.

[0070] The top temperature in the second deasphalting step is preferably 10-30°C lower and more preferably 15-25°C lower than the top temperature in the first deasphalting step. The bottom temperature
10 in the second deasphalting step is preferably 10-30°C lower and more preferably 15-25°C lower than the bottom temperature in the first deasphalting step.

[0071]

(First polar solvent extraction step (1))

15 The first polar solvent extraction step (1) is a step in which the first deasphalted oil and polar solvent are contacted in countercurrent flow in the first extraction column 30, to separate the first deasphalted oil into a first raffinate and a first extract, to obtain the first raffinate and the first extract. The polar solvent is appropriately recovered using a stripping
20 column or the like (not shown) provided at the downstream end of the first extraction column 30, and is circulated for reuse. The polar solvent may be a polar solvent such as furfural, phenol, cresol, sulfolane, N-methylpyrrolidone, dimethyl sulfoxide, formylmorpholine or a glycol-based solvent, but furfural is preferably used for this embodiment
25 from the viewpoint of allowing redeployment of solvent extraction equipment for common lubricant base oils.

[0072] The polar solvent is supplied to the first extraction column 30 through tubing 34. The first deasphalted oil is supplied to the first extraction column 30 through tubing 16. The first raffinate is obtained from tubing 36 and the first extract is obtained from tubing 38.

5 [0073] There are no particular restrictions on the extraction conditions, and they may be adjusted so that, for example, the 100°C dynamic viscosity of the first extract is preferably 30-70 mm²/s and more preferably 40-60 mm²/s. The extraction conditions in the first polar solvent extraction step may be, for example, as follows.

10 [0074]

- Solvent ratio: The volume ratio may be 1-5, preferably 2-4 and more preferably 2.5-3.5 based on the first deasphalted oil.

- Top temperature of first extraction column 30: This is preferably 100-150°C, more preferably 120-140°C and even more preferably 126-15

- Bottom temperature of first extraction column 30: This is preferably 60-130°C, more preferably 80-125°C and even more preferably 86-120°C.

- First extract yield: This is preferably 15-50 vol%, more preferably 20-20

40 vol% and even more preferably 25-33 vol%, based on the first deasphalted oil.

[0075]

(Second polar solvent extraction step (1))

25 The second polar solvent extraction step is a step in which the second deasphalted oil and a polar solvent are contacted in countercurrent flow in the second extraction column 40, for separation into a second extract

and a second raffinate, to obtain the second extract and second raffinate. The polar solvent is appropriately recovered using a stripping column or the like (not shown) provided at the downstream end of the second extraction column 40, and is circulated for reuse. The polar solvent used may be the same as in the first polar solvent extraction step (1). From the viewpoint of process simplification, preferably the same polar solvent is used in the first and second polar solvent extraction steps.

[0076] The polar solvent is supplied to the second extraction column 40 through tubing 44. The second deasphalted oil is supplied to the second extraction column 40 through tubing 26. The second raffinate is obtained from tubing 46 and the second raffinate is obtained from tubing 48.

[0077] There are no particular restrictions on the extraction conditions, and they are preferably adjusted so that, for example, the 100°C dynamic viscosity of the second extract is preferably 70-150 mm²/s, more preferably 80-120 mm²/s and even more preferably 90-100 mm²/s. The other extraction conditions may be the same as in the first polar solvent extraction step (1). Specifically, they may be as follows.

[0078]

- Solvent ratio: The volume ratio may be 1-5, preferably 2-4 and more preferably 2.5-3.5 based on the second deasphalted oil.

- Top temperature of second extraction column 40: This is preferably 100-150°C, more preferably 120-140°C and even more preferably 126-136°C.

- Bottom temperature of second extraction column 40: This is preferably 60-130°C, more preferably 80-125°C and even more preferably 86-

120°C.

· Second extract yield: This is 15-50 vol%, preferably 20-40 vol% and more preferably 25-33 vol%, based on the second deasphalted oil.

5 [0079] Component (A) of this embodiment may be obtained from the first extract of the first polar solvent extraction step (1) and/or the second extract of the second polar solvent extraction step (1). From the viewpoint of increasing the yield, component (A) is preferably the second extract.

[0080] (Second mode)

10 Component (A) of this embodiment may be obtained by the production process described below, instead of the first mode described above. According to this second mode, the second extract as component (A) is obtained by the two-stage polar solvent extraction step, from the vacuum distillation fraction of atmospheric distillation residue oil from
15 crude oil.

[0081]

(First polar solvent extraction step (2))

Fig. 2 is a process schematic diagram showing a second mode of a method for producing component (A). First, in the first polar solvent
20 extraction step (2), a vacuum distillation fraction of atmospheric distillation residue oil from crude oil, and a polar solvent, are contacted in a first extraction column 30 having a bottom temperature of 30-90°C and a top temperature that is higher than the bottom temperature, to obtain a first raffinate and a first extract.

25 [0082] The fraction of the vacuum distillation fraction used as starting material in the first polar solvent extraction step (2) is not particularly

restricted, and it may be the light lube-oil distillate, middle lube-oil distillate, heavy lube-oil distillate, or a blend thereof, or the entire vacuum distillation fraction may be used.

5 [0083] In order to raise the flash point of the aromatic-containing base oil and adjust component (B) to an appropriate viscosity range so that the viscosity is not too high, the 200-1500N, preferably 250-1200N and even more preferably 300-600N and/or 600-1200N lube-oil distillate, for example, may be used.

10 [0084] The denotation "N" as used herein means that it is a neutral oil obtained from the vacuum distillation fraction, and for example, 300N means that the viscosity at 100°F (37.8°C) is 300 Saybolt universal seconds (SUS).

15 [0085] For this mode, the vacuum distillation fraction of the atmospheric distillation residue oil from the crude oil is preferably selected so that a 200-1500N, preferably 250-600N and/or 600-1200N and more preferably 300-450N and/or 700-1000N lubricant base oil is obtained as component (B).

20 [0086] In the first polar solvent extraction step (2), the vacuum distillation fraction and a polar solvent are contacted in countercurrent flow in the first extraction column 30, to separate the first deasphalted oil into a first raffinate and a first extract, to obtain the first raffinate and the first extract. The polar solvent is appropriately recovered using a stripping column or the like (not shown) provided at the downstream end of the first extraction column 30, and is circulated for reuse. The
25 type of polar solvent may be the same as in the first polar solvent extraction step (1).

[0087] The polar solvent is supplied to the first extraction column 30 through tubing 34. The vacuum distillation fraction is supplied to the first extraction column 30 through tubing 16. The first raffinate is obtained from tubing 36 and the first extract is obtained from tubing 38.

5 [0088] The bottom temperature of the first extraction column 30 is 30-90°C, preferably 50-70°C and even more preferably 55-65°C. The top temperature of the first extraction column 30 is higher, preferably 10-50°C higher, more preferably 15-40°C higher and even more preferably 25-35°C higher, than the bottom temperature. More specifically, the
10 top temperature is preferably 60-120°C, more preferably 80-100°C and even more preferably 85-95°C.

[0089] The solvent ratio in the first polar solvent extraction step (2) is 0.5-3, preferably 0.7-2 and even more preferably 1-1.5. The "solvent ratio" referred to herein is the volume ratio of the solvent with respect to
15 the starting material (solvent volume/starting material).

[0090] The yield of the first raffinate obtained by the extraction conditions described above will usually be 50-90 vol%, and is preferably 60-85 vol% and more preferably 70-80 vol%. The first
20 extract yield will usually be 10-50 vol%, and is preferably 15-40 vol% and more preferably 20-30 vol%.

[0091] These extraction conditions will allow indicated aromatic compounds to be extracted at the first extract end. It will therefore be possible to sufficiently reduce the amount of indicated aromatic compounds in the lubricant base oil (component (B)) obtained from the
25 second extract and second raffinate obtained in the subsequent step.

[0092]

(Second polar solvent extraction step (2))

The second polar solvent extraction step (2) employs the first raffinate obtained in the first polar solvent extraction step (2) as the starting material. The first raffinate and a polar solvent are contacted in countercurrent flow in the second extraction column 41, for separation into a second extract and a second raffinate, to obtain the second extract and second raffinate. The polar solvent used may be the same as in the first polar solvent extraction step (2). From the viewpoint of process simplification, preferably the same polar solvent is used in the first and second polar solvent extraction steps.

[0093] The polar solvent is supplied to the second extraction column 41 through tubing 44. Also, the first raffinate is supplied to the second extraction column 41 through tubing 36. The second raffinate is obtained from tubing 47 and the second extract is obtained from tubing 49.

[0094] The bottom temperature of the second extraction column 41 is at least 10°C higher, preferably 10-50°C higher, more preferably 15-40°C higher and even more preferably 20-30°C higher, than the bottom temperature of the first extraction column 30 in the first polar solvent extraction step (1). More specifically, the bottom temperature of the second extraction column 41 is preferably 40-140°C, more preferably 60-100°C and even more preferably 80-95°C.

[0095] The top temperature of the second extraction column 41 is preferably 10-50°C, more preferably 15-40°C, even more preferably 25-35°C higher than the bottom temperature. More specifically, the top temperature of the second extraction column 41 is preferably 50-150°C,

more preferably 80-140°C and even more preferably 110-130°C.

[0096] The solvent ratio in the second polar solvent extraction step (2) is 1-4, preferably 1.3-3.5 and even more preferably 1.5-3.3, and preferably it is at least 1.5 times the solvent ratio in the first polar solvent extraction step (2).

[0097] These extraction conditions will result in a second raffinate yield of usually 50-90 vol%, preferably 60-85 vol% and more preferably 70-85 vol%, and a second extract yield of usually 10-50 vol%, preferably 15-40 vol% and more preferably 15-30 vol%.

[0098] The 15°C density of the obtained second extract is 0.94 g/cm³ or greater, and the total aromatic content according to ASTM D2549 is at least 30 mass%. Such a second extract may be used as component (A).

[0099] The 15°C density of the second extract is preferably 0.95-1 g/cm³ and more preferably 0.95-0.98 g/cm³. Also, the total aromatic content of the second extract is 30 mass% or greater, preferably 60 mass% or greater and more preferably 80 mass% or greater, and preferably no greater than 90 mass%. The total aromatic content referred to throughout the present specification was measured according to ASTM D2549.

[0100] The second extract has a %C_A value of preferably 15-35, preferably 20-33 and even more preferably 22-32, as measured according to ASTM D2140.

[0101] The second extract also has the following properties.

· Flash point: 250°C or higher, preferably 260°C or higher, and preferably no higher than 310°C.

· Pour point: No higher than 30°C, and preferably 10-30°C.

· Aniline point: No higher than 90°C, preferably 40-80°C and more preferably 50-70°C.

· Benzo(a)pyrene content: No greater than 1 ppm by mass.

· Total content of indicated aromatic compounds: No greater than 10 ppm by mass.

[0102]

(Method for producing component (B))

There are no particular restrictions on the method for producing component (B) for this embodiment. Component (B) can be obtained by extraction of a deasphalted oil obtained by deasphalting treatment of a vacuum distillation fraction of atmospheric distillation bottom oil from crude oil, or the vacuum distillation bottom oil of atmospheric distillation bottom oil from crude oil, using a polar solvent such as furfural, and subjecting the obtained raffinate to refining treatment including dewaxing and hydrofinishing.

[0103] Component (B) may be a hydrocracked mineral oil or hydroisomerized mineral oil, but it does not need to be of high quality beforehand. The use of a lubricant base oil with a total aromatic content of at least 30 mass%, obtained under relatively mild refining conditions, is preferred from the viewpoint of increasing suitability as a rubber compounding oil, and from the viewpoint of economy.

[0104] When component (A) having a 40°C dynamic viscosity of 2000 mm²/s or greater is used, the component (B) used is preferably a component (B) having a 40°C dynamic viscosity of 50-150 mm²/s and preferably 80-120 mm²/s, in order to obtain a rubber compounding oil with a suitable dynamic viscosity.

[0105] When using a component (A) having a 40°C dynamic viscosity of less than 2000 mm²/s, it is preferred to use a component (B) having a 40°C dynamic viscosity of 50-500 mm²/s, and preferably 60-80 mm²/s and/or 120-250 mm²/s, in order to obtain a rubber compounding oil with suitable dynamic viscosity.

[0106] Two different production methods (referred to as "first mode" and "second mode" for convenience) will now be explained in detail with reference to the accompanying drawings.

[0107]

(First mode)

(First polar solvent extraction step (3))

Fig. 3 is a process schematic diagram showing a first mode of a method for producing component (B).

[0108] In the first polar solvent extraction step (3), the vacuum distillation fraction of an atmospheric distillation residue oil from crude oil is used as the starting material. The vacuum distillation fraction and a polar solvent are contacted in countercurrent flow in the first extraction column 30, for separation into a first extract and a first raffinate, to obtain the first extract and first raffinate. The polar solvent is appropriately recovered using a stripping column or the like (not shown) provided at the downstream end of the first extraction column 30, and is circulated for reuse. The polar solvent used is the same as in the method for producing component (A).

[0109] The vacuum distillation fraction is the fraction corresponding to 200-800N, preferably the fraction corresponding to 350-700N and more preferably the fraction corresponding to 400-600N, in order to obtain a

lubricant base oil with a high flash point.

[0110] The polar solvent is supplied to the first extraction column 30 through tubing 34. The vacuum distillation fraction is supplied to the first extraction column 30 through tubing 16. The first raffinate is obtained from tubing 36 and the first extract is obtained from tubing 38.

[0111] The obtained first raffinate may be subjected to refining treatment with a dewaxing apparatus 50 and a hydrofinishing apparatus 60, to obtain a lubricant base oil as component (B). The dewaxing apparatus 50 and hydrofinishing apparatus 60 may be commonly used apparatuses.

[0112] The bottom temperature of the first extraction column 30 in the first polar solvent extraction step (3) is 30-90°C, preferably 60-80°C and even more preferably 65-75°C. On the other hand, the top temperature of the first extraction column 30 is higher, preferably 20-80°C higher, more preferably 30-70°C higher and even more preferably 40-60°C higher, than the bottom temperature. More specifically, the top temperature of the first extraction column 30 is preferably 80-160°C, more preferably 100-140°C and even more preferably 110-130°C.

[0113] The solvent ratio in the first polar solvent extraction step (3) is 0.5-4, preferably 1-3 and even more preferably 1.5-2.5.

[0114] These extraction conditions will result in a first raffinate yield of usually 40-80 vol%, preferably 50-70 vol% and more preferably 55-65 vol%, and a first extract yield of usually 20-60 vol%, preferably 30-50 vol% and more preferably 35-45 vol%.

[0115] Since indicated aromatic compounds are extracted at the first extract end by these extraction conditions, it is possible to adequately

reduce the content of indicated aromatic compounds in the lubricant base oil obtained from the first raffinate.

[0116] Next, the first raffinate is subjected to refining treatment including solvent dewaxing, hydrofinishing or the like, to obtain a lubricant base oil (component (B)) with a 40°C dynamic viscosity of 50-150 mm²/s and preferably 80-120 mm²/s.

[0117] If the starting material used is the vacuum distillation fraction corresponding to 400-600N, it will be possible to obtain a component (B) having a flash point of 250°C or higher, a 40°C dynamic viscosity of 50-150 mm²/s and preferably 80-120 mm²/s, and a 10% point of 430-480°C and a 90% point of 520-560°C in GC distillation.

[0118]

(Second mode)

Fig. 2 is a process schematic diagram showing a second mode of a method for producing component (B). For this mode, a second raffinate is obtained by the two-stage polar solvent extraction step and the second raffinate is subjected to refining treatment including dewaxing treatment, to obtain a lubricant base oil as component (B).

[0119]

20 (First polar solvent extraction step (4))

In the first polar solvent extraction step (4), the vacuum distillation fraction of an atmospheric distillation residue oil from crude oil is used as the starting material. This vacuum distillation fraction and a polar solvent are contacted in countercurrent flow in the first extraction column 30, for separation into a first extract and a first raffinate, to obtain the first extract and first raffinate. The polar solvent is

appropriately recovered using a stripping column or the like (not shown) provided at the downstream end of the first extraction column 30, and is circulated for reuse. The type of polar solvent may be the same as in the first mode.

5 [0120] The bottom temperature of the first extraction column 30 in the first polar solvent extraction step (4) is 30-90°C, and the top temperature is higher than the bottom temperature.

[0121]

(Second polar solvent extraction step (4))

10 Next, the first raffinate is contacted with a polar solvent in a second extraction column 41 having a bottom temperature and top temperature that are each at least 10°C higher than the bottom temperature and top temperature in the first polar solvent extraction step (4), to obtain a second raffinate and a second extract. The second raffinate may be
15 subjected to refining treatment with a dewaxing apparatus 50 and a hydrofinishing apparatus 60, to obtain a lubricant base oil as component (B). The dewaxing apparatus 50 and hydrofinishing apparatus 60 may be commonly used apparatuses.

[0122] This production method is a method in which the second
20 raffinate obtained by the same two-stage polar solvent extraction step described in detail for the second mode in "Method for producing component (A)", is subjected to refining treatment including dewaxing treatment, to obtain a lubricant base oil as component (B). This first polar solvent extraction step (4) and second polar solvent extraction step
25 (4) may be carried out in the same manner as the first polar solvent extraction step (2) and second polar solvent extraction step (2) described

above.

[0123] According to this production method, it is possible to obtain a 200-1500N, preferably 250-600N and/or 600-1200N and more preferably 300-450N and/or 700-1000N lubricant base oil (component (B)).

[0124] If the starting material used is the vacuum distillation fraction corresponding to 300-400N, it will be possible to obtain a component (B) having a flash point of 250°C or higher, a 40°C dynamic viscosity of 60-80 mm²/s, and a 10% point of 400-460°C and a 90% point of 500-540°C in GC distillation.

[0125] Also, if the starting material used is the vacuum distillation fraction corresponding to 700N-1000N, it will be possible to obtain a component (B) having a flash point of 250°C or higher, a 40°C dynamic viscosity of 120-250 mm²/s, and a 10% point of 450-520°C and a 90% point of 540-600°C in GC distillation.

[0126] The embodiments described above are only preferred embodiments of the invention, and the invention is in no way limited thereto. For example, in the production apparatus depicted in Fig. 1 used in the first mode of the method for producing component (A), the first and second raffinates may be refined by a dewaxing apparatus 50 and a hydrofinishing apparatus 60 provided at the respective downstream ends of the first extraction column 30 and the second extraction column 40, to obtain a lubricant base oil as component (B).

Examples

[0127] The present invention will now be explained in greater detail based on examples and comparative examples, with the understanding

that these examples are in no way limitative on the invention.

[0128] (Examples 1-3, Comparative Example 1)

[Production of component (A)]

5 The production apparatus shown in Fig. 1 was used to produce component (A). Specifically, a vacuum distillation residue oil of atmospheric distillation residue oil from crude oil was contacted with propane in a countercurrent flow in the first deasphalting column 10, for propane deasphalting of the vacuum distillation residue oil, and the first deasphalted oil and first asphalt oil (the bottom oil not extracted with propane) were separated (first deasphalting step).

10 [0129] In the first deasphalting step, the deasphalting conditions (solvent ratio, top temperature and bottom temperature) were adjusted so that the yield of the first deasphalted oil (the propane-distilled oil) was 1-20 vol% with respect to the vacuum distillation residue oil and the 100°C dynamic viscosity of the first deasphalted oil was 15-30 mm²/s. The solvent ratio was adjusted to 1-4 as the volume ratio based on the vacuum distillation residue oil, and the deasphalting column was adjusted to a range with a top temperature of 80-100°C and a bottom temperature of 60-90°C.

20 [0130] Next, the first asphalt oil was contacted with propane in countercurrent flow in the second deasphalting column 20, for propane deasphalting of the first asphalt oil, and the second deasphalted oil and second asphalt oil (the bottom oil not extracted with propane) were separated (second deasphalting step).

25 [0131] In the second deasphalting step, the deasphalting conditions (solvent ratio, top temperature and bottom temperature) were adjusted

so that the yield of the second deasphalted oil (the propane-distilled oil) was 15-50 vol% with respect to the vacuum distillation residue oil as the starting material of the first deasphalting step, and so that the 100°C dynamic viscosity of the second deasphalted oil was 30-60 mm²/s.

5 The solvent ratio was greater than in the first deasphalting step, and the top temperature and bottom temperature of the second deasphalting column 20 were lower than the top temperature and bottom temperature, respectively, of the first deasphalting column 10. Specifically, the solvent ratio was adjusted to 4-8 as the volume ratio based on the first asphalt oil, and the top temperature and bottom temperature were adjusted to ranges of 60-90°C and 40-80°C, respectively.

[0132] Table 1 shows the deasphalting conditions in the first deasphalting step and second deasphalting step and the yields of the obtained deasphalted oil and asphalt oil.

15 [0133] [Table 1]

Production step	First deasphalting step	Second deasphalting step
Starting material	Vacuum distillation residue oil	First asphalt oil
Solvent	Propane	Propane
Solvent ratio	2.0	6.0
Column top temperature °C	90	70
Column bottom temperature °C	78	55
Deasphalted oil	First deasphalted oil	Second deasphalted oil
Yield (with respect to vacuum distillation residue oil) vol%	4	30
Dynamic viscosity (100°C) mm ² /s	23	40
Asphalt oil (bottom)	First asphalt oil	Second asphalt oil

[0134] Next, the first deasphalted oil and second deasphalted oil were contacted with furfural in countercurrent flow in the first extraction column 30 and second extraction column 40, respectively, to obtain a first extract A1 and second extract A2 (first polar solvent extraction step

(1) and first polar solvent extraction step (2)).

[0135] In the first polar solvent extraction step (1), the extraction conditions (solvent ratio, and top temperature and bottom temperature of first extraction column 30) were adjusted so that the 100°C dynamic viscosity of the first extract was 30-70 mm²/s, the first extract yield was 15-45 vol% with respect to the first deasphalted oil, the aniline point was no higher than 90°C, the flash point was 250°C or higher, and the asphaltene content was no greater than 3 mass%. Specifically, the solvent ratio was adjusted to 2-4 as the volume ratio based on the first deasphalted oil, the top temperature was adjusted to 100-150°C, and the bottom temperature was adjusted to 60-130°C.

[0136] In the first polar solvent extraction step (2), the extraction conditions (solvent ratio, and top temperature and bottom temperature of second extraction column 40) were adjusted so that the 100°C dynamic viscosity of the second extract was 70-150 mm²/s, the second extract yield was 15-45 vol% with respect to the second deasphalted oil, the aniline point was no higher than 90°C, the flash point was 250°C or higher, and the asphaltene content was no greater than 3 mass%. Specifically, the solvent ratio was adjusted to 2-4 as the volume ratio based on the second deasphalted oil, the top temperature was adjusted to 100-150°C, and the bottom temperature was adjusted to 60-130°C.

[0137] Table 2 shows the extraction conditions in the first polar solvent extraction step (1) and first polar solvent extraction step (2), and the yields of the first extract A1 and second extract A2. The first extract A1 and second extract A2 were not subjected to refining treatment.

[0138] [Table 2]

Production step	First polar solvent extraction step (1)	First polar solvent extraction step (2)
Starting material	First deasphalted oil	Second deasphalted oil
Polar solvent	Furfural	Furfural
Solvent ratio	2.5	2.8
Column top temperature °C	130	130
Column bottom temperature °C	85	90
Extract	First extract A1	Second extract A2
Yield (with respect to starting material) vol%	18	30
Refining step	None	None

[0139]

[Production of component (B)]

5 The production apparatus shown in Fig. 3 was used to produce component (B). Specifically, a 500N-corresponding fraction was prepared as a vacuum distillation fraction of atmospheric distillation residue oil from crude oil. The 500N-corresponding fraction was contacted with furfural in countercurrent flow in the first extraction column 30, to obtain a first raffinate and a first extract C (first polar solvent extraction step (3)).

10 [0140] The bottom temperature of the first extraction column 30 was 30-90°C, and the top temperature was a higher temperature than the bottom temperature. The obtained first raffinate was subjected to refining treatment including dewaxing treatment and hydrofinishing treatment to obtain a lubricant base oil B1. Table 3 shows the extraction conditions in the first polar solvent extraction step (3), and the yields of the first raffinate and first extract C.

15 [0141] [Table 3]

Production step	First polar solvent extraction step (3)
Starting material	Vacuum distillation residue (corresp. to 500N)
Polar solvent	Furfural
Solvent ratio	2.0
Column top temperature °C	120
Column bottom temperature °C	72
Raffinate	First raffinate
Yield (with respect to starting material) vol%	60
Refining step	MEK dewaxing, hydrofinishing (Lubricating base oil B1)
Extract	First extract C
Yield (with respect to starting material) vol%	40
Refining step	None

[0142] Table 4 shows the properties of the first extract A1 (base material 1) obtained in the first polar solvent extraction step (1), the second extract A2 (base material 2) obtained in the first polar solvent extraction step (2), the first extract C (base material 3) obtained in the first polar solvent extraction step (3) and the lubricant base oil B1 (base material 4) obtained by refining treatment of the first raffinate obtained in the first polar solvent extraction step (3).

[0143] [Table 4]

	Base material 1	Base material 2	Base material 3	Base material 4
(A) First extract A1	100	-	-	-
(A) Second extract A2	-	100	-	-
First extract C	-	-	100	-
(B) Lubricating base oil B1	-	-	-	100
Density (15°C) g/cm ³	0.9712	0.9998	1.01	0.8867
Flash point (COC) °C	320	318	-	270
Dynamic viscosity (40°C) mm ² /s	1840	7272	-	100.4
Dynamic viscosity (100°C) mm ² /s	49.23	94.46	30.7	11.18
Aniline point °C	69	58	39	109
Nitrogen content mass%	0.15	0.18	-	0.005
Composition (ASTM D3238)				
%C _P	61.0	55.8	-	66.1
%C _N	9.1	8.0	-	27.1
%C _A	29.9	36.2	-	6.8
Composition (ASTM D2549)				
Saturated content mass%	-	2.3	-	62.2
Total aromatic content mass%	-	69.3	-	37.3
Benzo (a) pyrene ppm by mass	<1	<1	>1	<1
Specific aromatic compound total ppm by mass	<10	<10	>10	<10
GC distillation				
T10 °C	-	-	-	458
T90 °C	-	-	-	538
Pour point °C	15	12.5	-	-12.5

[0144] As seen in Table 4, the first extract A1 and second extract A2 both had indicated aromatic compound contents below the specified level (10 ppm). On the other hand, the first extract C obtained from the first polar solvent extraction step (3) of the vacuum distillation fraction had an indicated aromatic compound content exceeding the specified level.

[0145] The second extract A2 and lubricant base oil B1 obtained as described above were combined in the proportions listed in Table 5 to prepare rubber compounding oils for Examples 1-3. Also, the first extract C and lubricant base oil B1 were combined in the proportion listed in Table 5 to prepare a rubber compounding oil for Comparative Example 1. The properties of the rubber compounding oils are shown in Table 5.

[0146] The predicted pour points in Table 5 were calculated from (A) the pour point of the second extract A2 and (B) the pour point of the lubricant base oil B1, assuming establishment of additive property.

[0147] [Table 5]

5

		Example 1	Example 2	Example 3	Comp. Ex. 1
(A) Second extract A2		80	60	50	-
First extract C		-	-	-	60
(B) Lubricating base oil B1		20	40	50	40
Density (15°C)	g/cm ³	0.9757	0.9517	0.9407	0.96
Flash point (COC)	°C	298	284	282	-
Dynamic viscosity (40°C)	mm ² /s	1961	693.4	448.3	-
Dynamic viscosity (100°C)	mm ² /s	50.66	30.37	24.54	19.70
Aniline point	°C	70	81.3	86.3	68
Nitrogen content	mass%	0.15	0.11	0.10	-
Composition (ASTM D3238)					
%C _P		58.4	61.2	62.4	-
%C _N		12.2	15.7	17.8	-
%C _A		29.5	23.1	19.8	-
Composition (ASTM D2549)					
Saturated content	mass%	14.3	26.1	32.3	-
Total aromatic content	mass%	63.0	54.2	53.5	-
Benzo (a) pyrene	ppm by mass	<1	<1	<1	>1
Specific aromatic compound total	ppm by mass	<10	<10	<10	>10
Predicted pour point	°C	7.5	2.5	0	-
Pour point	°C	0	-5	-5	-

[0148] Table 5 shows that the rubber compounding oils of Examples 1-3 were at least 5°C lower than the predicted pour points calculated from the pour points of the base materials. Also, the indicated aromatic compound contents of the rubber compounding oils of Examples 1-3 were confirmed to be lower than the specified level. In particular, the rubber compounding oil of Example 2 had a pour point of -5°C, which was 7.5°C lower than the predicted pour point. In contrast, the rubber compounding oil of Comparative Example 1 had an indicated aromatic compound content exceeding the specified level.

[0149] The composition of the rubber compounding oil of Example 2

was analyzed according to ASTM D2007 (Clay-gel method), and as a result the saturated component content was 30.5 mass%, the aromatic content was 61.3 mass%, the polar compound content was 8.2 mass% and the saturated component/polar compound ratio was 3.7.

5 [0150] (Examples 4 and 5, Comparative Examples 2 and 3)

[Production of component (A)]

10 The production apparatus shown in Fig. 2 was used to produce component (A). Specifically, the vacuum distillation fraction of atmospheric distillation residue oil from crude oil (350N-corresponding fraction) was contacted with furfural in countercurrent flow in the first extraction column 30, and the 350N-corresponding fraction was separated into a first raffinate and a first extract D. The bottom temperature of the first extraction column 30 was 30-90°C (first polar solvent extraction step (2)).

15 [0151] Next, the first raffinate and furfural were contacted in countercurrent flow in the second extraction column 41, and the first raffinate was separated into a second raffinate and a first extract A3 (second polar solvent extraction step (2)). The top temperature and bottom temperature of the second extraction column 41 in the second
20 polar solvent extraction step (2) were each at least 10°C higher than the top temperature and bottom temperature of the first extraction column 30 in the first polar solvent extraction step (2).

[0152] There were thus obtained a second raffinate and a second extract A3 having a 15°C density of 0.94 g/cm³ or greater and a total aromatic
25 content of 30 mass% or greater as measured according to ASTM D2549.

[0153] Table 6 shows the extraction conditions in the first polar solvent

extraction step (2) and second polar solvent extraction step (2), and the yields of each raffinate and extract.

[0154] [Table 6]

Production step	First polar solvent extraction step (2)	Second polar solvent extraction step (2)
Starting material	Vacuum distillation residue (350N)	First raffinate (of previous column)
Polar solvent	Furfural	Furfural
Solvent ratio	1.3	2.0
Column top temperature °C	90	116
Column bottom temperature °C	60	85
Raffinate	First raffinate	Second raffinate
Yield (with respect to starting material) vol%	74	80
Specific aromatic compound total ppm by mass	<10	<10
Extract	First extract D	Second extract A3
Yield (with respect to starting material) vol%	26	20
Specific aromatic compound total ppm by mass	>10	<10

[0155] In addition, a first polar solvent extraction step (2) and a second polar solvent extraction step (2) were conducted using the production apparatus shown in Fig. 2, in the same manner as the first polar solvent extraction step (2) and the second polar solvent extraction step (2), except that a vacuum distillation fraction of atmospheric distillation residue oil from crude oil (900N-corresponding fraction) was used as starting material and the extraction conditions were slightly changed, to obtain a first raffinate and a first extract E from the first extraction column 30, and a second raffinate and a second extract A4 having a 15°C density of 0.94 g/cm³ or greater and a total aromatic content of 30 mass% or greater as measured according to ASTM D2549, from the second extraction column 41.

[0156] Table 7 shows the extraction conditions in the first polar solvent extraction step (2) and second polar solvent extraction step (2) using a 900N-corresponding fraction as the vacuum distillation fraction, and the

yields of each raffinate and extract.

[0157] [Table 7]

Production step	First polar solvent extraction step (2)	Second polar solvent extraction step (2)
Starting material	Vacuum distillation residue (900N)	First raffinate (of previous column)
Polar solvent	Furfural	Furfural
Solvent ratio	1.2	2.1
Column top temperature °C	90	121
Column bottom temperature °C	60	90
Raffinate	First raffinate	Second raffinate
Yield (with respect to starting material) vol%	75	75
Specific aromatic compound total ppm by mass	<10	<10
Extract	First extract E	Second extract A4
Yield (with respect to starting material) vol%	25	25
Specific aromatic compound total ppm by mass	>10	<10

5 [0158] The first extracts D and E in Table 6 and Table 7 had indicated aromatic compound contents exceeding 10 ppm by mass.

[0159] The second raffinates in Tables 6 and 7 were then subjected to MEK dewaxing treatment and hydrofinishing treatment to obtain lubricant base oils B2 and B3, respectively. Also, the obtained second
 10 extract A3 and second extract A4 were mixed at 37.5:62.5 (mass ratio) to obtain a second extract A5 having a 40°C dynamic viscosity of less than 650 mm²/s.

[0160] The properties of the second extracts A4 and A5 and the lubricant base oils B2 and B3 obtained in this manner are shown in
 15 Table 8.

[0161] [Table 8]

		Base material 5	Base material 6	Base material 7	Base material 8
(A) Second extract A4		100	-	-	-
Second extract A5		-	100	-	-
(B) Lubricating base oil B2		-	-	100	-
(B) Lubricating base oil B3		-	-	-	100
Density (15°C)	g/cm ³	0.9768	0.9680	0.8827	0.8941
Flash point (COC)	°C	296	283	260	284
Dynamic viscosity (40°C)	mm ² /s	1090	588	74.34	170
Aniline point	°C	59.7	60.5	99.0	112.0
Nitrogen content	mass%	0.08	0.06	0.004	0.008
Composition (ASTM D3238)					
%C _P		57.5	57.1	67.6	68.1
%C _N		9.7	13.4	26.9	24.7
%C _A		32.8	29.4	5.6	7.3
Composition (ASTM D2549)					
Saturated content	mass%	9.0	11.4	65.5	55.5
Total aromatic content	mass%	86.9	85.2	33.9	43.8
Benzo(a)pyrene	ppm by mass	<1	<1	<1	<1
Specific aromatic compound total	ppm by mass	<10	<10	<10	<10
GC distillation					
T10	°C	-	-	443	481
T90	°C	-	-	518	573
Pour point	°C	20	22.5	-12.5	-12.5

[0162] The second extract A4 and lubricant base oil B2 or B3 obtained as described above were combined in the proportions listed in Table 9 to prepare rubber compounding oils for Examples 4 and 5. Also, the second extract A5 or first extract E and the (B) lubricant base oil B3 were combined in the proportions listed in Table 9 to prepare rubber compounding oils for Comparative Examples 2 and 3. The properties of the rubber compounding oils are shown in Table 9.

[0163] [Table 9]

	Example 4	Example 5	Comp. Ex. 2	Comp. Ex. 3
(A) Second extract A4	67	80	-	-
Second extract A5	-	-	80	-
First extract E	-	-	-	80
(B) Lubricating base oil B2	-	20	-	-
(B) Lubricating base oil B3	33	-	20	20
Density (15°C) g/cm ³	0.95	0.9585	0.953	-
Flash point (COC) °C	294	276	283	-
Dynamic viscosity (40°C) mm ² /s	501	544	450	-
Dynamic viscosity (100°C) mm ² /s	24.83	24.97	22.1	-
Aniline point °C	78.7	71	71	-
Nitrogen content mass%	0.06	0.06	0.05	-
Composition (ASTM D3238)				
%C _P	61.2	60.1	59.3	-
%C _N	15.8	14.1	15.7	-
%C _A	23.0	25.8	25.0	-
Composition (ASTM D2549)				
Saturated content mass%	23.1	22.1	20.0	-
Total aromatic content mass%	73.9	73.5	77.0	-
Benzo(a)pyrene ppm by mass	<1	<1	<1	>1
Specific aromatic compound total ppm by mass	<10	<10	<10	>10
Predicted pour point °C	9.3	13.5	15.5	-
Pour point °C	-2.5	-5	20	-

[0164] The predicted pour points in Table 9 were calculated from (A) the pour point of the second extract A2 and (B) the pour point of the lubricant base oil B1, and their mixing ratio, assuming establishment of additive property.

[0165] Table 9 shows that the rubber compounding oils of Examples 4 and 5 were at least 5°C lower than the predicted pour points calculated from the pour points of the base materials. Also, the contents of the indicated aromatic compounds of the rubber compounding oils of Examples 4 and 5 were below the specified level (10 ppm). In contrast, the rubber compounding oil of Comparative Example 2 had a higher value than the predicted pour point, while the rubber compounding oil of Comparative Example 3 had an indicated aromatic compound content exceeding the specified level.

[0166] The glass transition point (T_g) was measured for each of the rubber compounding oils of Example 1, Example 2, Example 3, Example 4 and Example 5 by the method described above using a DSC (differential scanning calorimeter), yielding results of -44.5°C , -51.3°C , -55.0°C , -52.5°C and -51.7°C , respectively. In other words, the rubber compounding oils of Examples 1-5, comprising mixtures of specific extracts and lubricant base oils, satisfy the conditions of Patent document 1, i.e. a $\%C_A$ of 20-35, a glass transition temperature T_g of between -55°C and -30°C and a dynamic viscosity (100°C) of 20-50 mm^2/s , while also limiting the total content of indicated aromatic compounds (PAH) to no greater than the specified levels, and having lower pour points than the predicted pour points.

[0167] Thus, if the rubber compounding oils of Examples 1-5 are added to for example, natural rubber (NR), or diene rubbers including various butadiene rubbers (BR), various styrene-butadiene copolymer rubbers (SBR), polyisoprene rubber (IR), butyl rubber (BR) and any blended rubbers thereof, and especially to diene rubbers comprising at least one type of styrene-butadiene copolymer rubber, it will be possible to obtain low fuel consumption and satisfactory grip properties, as well as to improve the thermal aging resistance and wear resistance.

Industrial Applicability

[0168] According to the invention it is possible to provide a rubber compounding oil having a high flash point and high aromaticity, with an adequately reduced content of indicated aromatic compounds, a low pour point, and excellent economy, as well as a method for producing it.

Explanation of Symbols

[0169] 10: First deasphalting column, 20: second deasphalting column, 30: first extraction column, 40,41: second extraction columns, 50: dewaxing apparatus, 60: hydrofinishing apparatus.

CLAIMS

1. A rubber compounding oil comprising:

an extract (A) having

an aniline point of 40-90°C,

5 a %C_A of 25-45 and a %C_N of 5-20 according to ASTM D3238,

a nitrogen content of 0.01 mass% or greater,

a pour point of no higher than +30°C,

a benzo(a)pyrene content of no greater than 1 ppm by mass,

a total content of indicated aromatic compounds of no greater

10 than 10 ppm by mass, and

a 40°C dynamic viscosity of 650 mm²/s or greater; and

a lubricant base oil (B) having

a pour point of no higher than -10°C,

an aniline point of 70°C or higher,

15 a %C_A of 3-20 and a %C_N of 15-35 according to ASTM D3238,

a nitrogen content of no greater than 0.01 mass%,

a 90% point of 500°C or higher in GC distillation,

a flash point of 250°C or higher,

a benzo(a)pyrene content of no greater than 1 ppm by mass and

20 a total content of indicated aromatic compounds of no greater than 10 ppm by mass.

2. The rubber compounding oil according to claim 1,

wherein the extract (A) is an extract obtained by extraction by contacting a polar solvent with deasphalted oil obtained by deasphalting
25 of a vacuum distillation residue oil of atmospheric distillation residue oil from crude oil, in one or two stages.

3. The rubber compounding oil according to claim 1,

wherein the extract (A) includes an extract obtained by a two-stage polar solvent extraction step, the extract being obtained by contacting a polar solvent with a raffinate obtained by contacting a polar solvent with a vacuum distillation fraction of atmospheric distillation residue oil from crude oil in a first extraction column having a bottom temperature of 30-90°C and a top temperature that is higher than the bottom temperature, in a second extraction column having a bottom temperature and top temperature that are at least 10°C higher than those of the first extraction column,

wherein the extract has a 15°C density of 0.94 g/cm³ or greater and a total aromatic content of 30 mass% or greater according to ASTM D2549.

4. The rubber compounding oil according to any one of claims 1 to 3,

wherein the lubricant base oil (B) comprises a dewaxing oil (c) of a first raffinate obtained by a one-stage polar solvent extraction step and/or a dewaxing oil (d) of a second raffinate obtained by a two-stage polar solvent extraction step,

the dewaxing oil (c) being obtained by refining treatment including a dewaxing step on a first raffinate obtained by contacting a polar solvent with a vacuum distillation fraction of an atmospheric distillation residue oil from a crude oil in a first extraction column having a bottom temperature of 30-90°C and a top temperature that is higher than the bottom temperature, and

the dewaxing oil (d) being obtained by refining treatment including a dewaxing step on a second raffinate obtained by contacting

a polar solvent with the first raffinate, in a second extraction column having a bottom temperature and a top temperature that are at least 10°C higher than those of the first extraction column.

5. A method for producing a rubber compounding oil comprising:

5 a step of mixing

an extract (A) having an aniline point of 40-90°C, a %C_A of 25-45 and a %C_N of 5-20 according to ASTM D3238, a nitrogen content of 0.01 mass% or greater, a pour point of no higher than +30°C, a benzo(a)pyrene content of no greater than 1 ppm by mass, a total
10 content of indicated aromatic compounds of no greater than 10 ppm by mass, and a 40°C dynamic viscosity of 650 mm²/s or greater, with

a lubricant base oil (B) having a pour point of no higher than -10°C, an aniline point of 70°C or higher, a %C_A of 3-20 and a %C_N of 15-35 according to ASTM D3238, a nitrogen content of no greater than
15 0.01 mass%, a 90% point of 500°C or higher in GC distillation, a flash point of 250°C or higher, a benzo(a)pyrene content of no greater than 1 ppm by mass and a total content of indicated aromatic compounds of no greater than 10 ppm by mass.