

A METHOD FOR PREDICTING A PROPERTY OF A BASE OIL

FIELD OF THE INVENTION

This invention is directed to a method for predicting a property of a base oil and to a blend chart.

SUMMARY

In a first aspect, there is provided a method for predicting a property of a base oil, comprising:

- a. selecting a first base stock and a second base stock;
- b. preparing a chart having:
 - i. a first point with a first viscometric property under low temperature and a first volatility of the first base stock;
 - ii. a second point with a second viscometric property under low temperature and a second volatility of the second base stock;
- c. blending the first base stock and the second base stock in varying proportions to construct a curve between the first point and the second point on the chart; wherein the curve predicts whether a base oil that is a blend of the first base stock and the second base stock will meet base oil requirements for a finished lubricant;
- d. if the curve falls below a point representing the base oil requirements for the finished lubricant, then the base oil blend of the first base stock and the second base stock are capable of making the finished lubricant;
- e. if the curve falls above the point representing the base oil requirements for the finished lubricant, then the correct type of a trim stock is ascertained by a direction and a distance one would need to shift the curve.

In a second aspect, there is provided a blend chart, comprising:

- a. a first point defined by a first viscometric property and a first volatility of a first base stock;
- b. a second point defined by a second viscometric property and a second volatility of a second base stock;
- c. a curve drawn between the first point and the second point that predicts a third viscometric property and a third volatility of one or more

- blends of the first base stock and the second base stock; and
- d. one or more target ranges enclosing desired values of a fourth viscometric property and a fourth volatility that are required to meet a specification for a finished lubricant; wherein the position of the curve relative to the one or more target ranges predicts whether a blend of the first base stock and the second base stock will meet the specification for the finished lubricant.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 illustrates a blend chart having curves defining the typical relationship between CCS VIS @-25°C and Noack volatility of blends of Chevron 100R with Chevron 220R, Chevron 110RLV and Chevron 220R, Chevron 5R and Chevron 220R, Chevron 4R and Chevron 220R, and Chevron 110RLV and Chevron 7R. The circle to the left encompasses the target range of CCS VIS and Noack volatility needed for 5W multigrade engine oils. The circle in the center encompasses the target range of CCS VIS and Noack volatility needed for 10W multigrade engine oils. The circle to the right encompasses the target range of CCS VIS and Noack volatility needed for 15W multigrade engine oils.

Chevron 110RLV is a new base oil with improved properties. Chevron 100R, 150R, and Chevron 220R are commercial Group II base oils. Chevron 4R, 5R, and 7R are commercial highly paraffinic unconventional base oils. Chevron 4R and Chevron 7R are Group III base oils, and Chevron 5R is a Group II base oil.

FIGURE 2 illustrates a blend chart having a first point defined by the CCS VIS and Noack volatility of Chevron 100R. The blend chart has a second point defined by the CCS VIS and Noack volatility of Chevron 7R. The blend chart has a third point defined by the CCS VIS and Noack volatility of Chevron 220R. Curves are drawn between the three points. A target point of a CCS VIS of 3342 and a Noack volatility of 11.73 is placed on the chart. The chart instructs a user how much of each of the three base oils may be blended to meet the target point properties.

DETAILED DESCRIPTION OF THE INVENTION

Definitions:

The term "comprising" means including the elements or steps that are identified following that term, but any such elements or steps are not
5 exhaustive, and an embodiment may include other elements or steps.

"Consecutive numbers of carbon atoms" means that the base oil has a distribution of hydrocarbon molecules over a range of carbon numbers, with every number of carbon numbers in-between. For example, the base oil may have hydrocarbon molecules ranging from C22 to C36 or from C30 to C60

10 with every carbon number in-between. The hydrocarbon molecules of the base oil differ from each other by consecutive numbers of carbon atoms, as a consequence of the waxy feed used to make the base oil also having consecutive numbers of carbon atoms. For example, in the Fischer-Tropsch hydrocarbon synthesis reaction, the source of carbon atoms is CO and the
15 hydrocarbon molecules are built up one carbon atom at a time. Petroleum-derived waxy feeds have consecutive numbers of carbon atoms. In contrast to an oil based on polyalphaolefin, the molecules of a base oil made from a waxy feed and having consecutive numbers of carbon atoms have a more linear structure, comprising a relatively long backbone with short branches.

20 The classic textbook description of a polyalphaolefin is a star-shaped molecule, and in particular tridecane, which is illustrated as three decane molecules attached at a central point. While a star-shaped molecule is theoretical, nevertheless polyalphaolefin molecules have fewer and longer branches than the hydrocarbon molecules that make up the base oil disclosed
25 herein.

A "base stock" is a lubricant component that is produced by a single manufacturer to the same specifications (independent of feed source or manufacturer's location); that meets the same manufacturer's specification; and that is identified by a unique formula, product identification number, or
30 both. Base stocks may be manufactured using a variety of different processes including but not limited to distillation, solvent refining, hydrogen processing, oligomerization, esterification, and rerefining.

A "base oil" is a base stock or blend of different base stocks. It is suitable for blending with additives into finished lubricants meeting desired specifications.

5 A "base stock slate" is a product line of base stocks that have different viscosities but are in the same base stock grouping and from the same manufacturer.

A "light neutral base oil" has a boiling range of approximately 650°F to 900°F (343°C to 482°C), a pour point not greater than about -5°C, and a kinematic viscosity at 100°C of about 4 to about 5 mm²/s.

10 A "highly paraffinic unconventional base oil" is a Group II or Group III base oil having greater than 72% paraffinic carbon and less than 30% naphthenic carbon by n-d-M analysis.

N-d-M analysis is done by ASTM D3238-95 (Reapproved 2005) with normalization. ASTM D3238-95 (Reapproved 2005) is the Standard Test
15 Method for Calculation of Carbon Distribution and Structural Group Analysis of Petroleum Oils by the n-d-M Method. This method is for "olefin free" feedstocks which are assumed in this application to mean that that olefin content is 2 wt% or less. The normalization process consists of the following:

20 A) If the Ca value is less than zero, Ca is set to zero, and Cn and Cp are increased proportionally so that the sum is 100%. B) If the Cn value is less than zero, Cn is set to zero, and Ca and Cp are increased proportionally so that the sum is 100%; and C) If both Cn and Ca are less than zero, Cn and Ca are set to zero, and Cp is set to 100%.

25 Test Method Descriptions:

"Boiling range" is the 5 wt% boiling point to the 95 wt%, inclusive of the end points, as measured by ASTM D 6352-04 and referred to herein as SimDist. A hydrocarbon with a boiling range of 700 to 900°F, for example has
30 a 5 wt% boiling point greater than 700°F and a 95 wt% boiling point less than 900°F.

"Kinematic viscosity" is a measurement in mm²/s of the resistance to flow of a fluid under gravity, determined by ASTM D445-06.

"Viscosity index" (VI) is an empirical, unit-less number indicating the effect of temperature change on the kinematic viscosity of the oil. The higher the VI of an oil, the lower its tendency to change viscosity with temperature. VI is measured according to ASTM D 2270-04.

5 "Cold-cranking simulator apparent viscosity" (CCS VIS) is a measurement in millipascal seconds, mPa.s, to measure the viscometric properties of lubricating base oils under low temperature and low shear. CCS VIS is determined by ASTM D 5293-04. CCS VIS may be measured at different temperatures, such as -25°C or -35°C.

10 "Noack volatility" is defined as the mass of oil, expressed in weight %, which is lost when the oil is heated at 250°C with a constant flow of air drawn through it for 60 minutes, measured according to ASTM D5800-05, Procedure B.

"Pour point" is a measurement of the temperature at which a sample of
15 base oil will begin to flow under certain carefully controlled conditions, which can be determined as described in ASTM D 5950-02.

"Flash point" is a measure of the tendency of the base oil to form a flammable mixture with air under controlled laboratory conditions. It is measured using a Cleveland open cup apparatus (manual or automated), by
20 ASTM D 92-05a.

"Oxidator BN" measures the response of a base oil in a simulated application. High values, or long times to adsorb one liter of oxygen, indicate good stability. Oxidator BN can be measured via a Dornite-type oxygen absorption apparatus (R. W. Dornite "Oxidation of White Oils," Industrial and
25 Engineering Chemistry, Vol. 28, page 26, 1936), under 1 atmosphere of pure oxygen at 340°F. The time, in hours, to absorb 1000 ml of O₂ by 100 grams of oil is reported. In the Oxidator BN test, 0.8 ml of catalyst is used per 100 grams of oil. The catalyst is a mixture of soluble metal-naphthenates simulating the average metal analysis of used crankcase oil. The additive
30 package is 80 millimoles of zinc bispolypropylenephenyldithiophosphate per 100 grams of oil.

"Weight percent aromatics" gives an indication of the UV and oxidation stability of a base oil. It can be measured by HPLC-UV. In one embodiment,

the test is conducted using a Hewlett Packard 1050 Series Quaternary Gradient High Performance Liquid Chromatography (HPLC) system, coupled with a HP 1050 Diode-Array UV-Vis detector interfaced to an HP Chemstation. Identification of the individual aromatic classes in the base oil can be made on the basis of the UV spectral pattern and the elution time. The amino column used for this analysis differentiates aromatic molecules largely on the basis of their ring- number (or double-bond number). Thus, the single ring aromatic containing molecules elute first, followed by the polycyclic aromatics in order of increasing double bond number per molecule. For aromatics with similar double bond character, those with only alkyl substitution on the ring elute sooner than those with naphthenic substitution. Unequivocal identification of the various base oil aromatic hydrocarbons from their UV absorbance spectra can be accomplished recognizing that their peak electronic transitions are all red-shifted relative to the pure model compound analogs to a degree dependent on the amount of alkyl and naphthenic substitution on the ring system. Quantification of the eluting aromatic compounds can be made by integrating chromatograms made from wavelengths optimized for each general class of compounds over the appropriate retention time window for that aromatic. Retention time window limits for each aromatic class can be determined by manually evaluating the individual absorbance spectra of eluting compounds at different times and assigning them to the appropriate aromatic class based on their qualitative similarity to model compound absorption spectra.

25 Base Oil

We have developed an improved base oil comprising hydrocarbons with consecutive numbers of carbon atoms. In one embodiment, the base oil has a boiling range from 700 to 925°F (371 to 496°C), a VI from 105 to 115, and a Noack volatility less than 18 wt%.

30 In a second embodiment, the base oil has a boiling range from 700 to 925°F (371 to 496°C), a VI from 105 to 115, and a CCS VIS at -25°C less than 1500 mPa.s.

In a third embodiment, the base oil has a boiling range from 700 to 925°F (371 to 496°C), a CCS VIS at -25°C of at least 1100 mPa.s, and a ratio of Noack volatility to CCS VIS at -25°C multiplied by 100 from 0.80 to 1.55.

The base oil has a VI that is less than 120, such that the base oil falls
5 with the VI range of a Group II base oil. In some embodiments the VI is from 105 to 115, such as from 107 to 115, 107 to 113, 109 to 114, or 110 to 115.

The base oil has a low Noack volatility, generally less than 25 wt% or less than 20 wt%. In some embodiments the Noack volatility is less than 18 wt%, less than 17 wt%, or less than 16.5 wt%.

10 In one embodiment the base oil has an Oxidator BN that is greater than 18, 20, 22, or 24 hours. In some embodiments the Oxidator BN of the base oil is higher than the original Oxidator BN of an original base oil from which the base oil is made.

In one embodiment the base oil has a high flash point, such as greater
15 than 210°C, greater than 215°C, or greater than 220°C. Generally, the base oil has a flash point less than 275°C.

In one embodiment the base oil has a low wt% total aromatics, such as less than 0.20 wt%, less than 0.10 wt%, or less than 0.05 wt%.

One feature of the base oil is that it can be blended into a wide variety
20 of high quality finished lubricants by blending the base oil with one or more additives. Examples of finished lubricants that can be made from the base oil include engine oils, greases, heavy duty motor oils, passenger car motor oils, transmission and torque fluids, natural gas engine oils, marine lubricants, railroad lubricants, aviation lubricants, food processing lubricants, paper and
25 forest products, metalworking fluids, gear lubricants, compressor lubricants, turbine oils, hydraulic oils, heat transfer oils, barrier fluids, and other industrial products. In one embodiment the base oil can be blended into a multigrade engine oil. Examples of multigrade engine oils that can be blended with the base oil are 5W-XX, 10W-XX, and 15W-XX, wherein XX is selected from the
30 group consisting of 20, 30, 40, 50, and 60.

The base oil may additionally comprise a second base oil. In one embodiment the second base oil is a Group II base oil. Group II, Group III, and Group IV base oils are defined in Appendix E of the API 1509.

specification, April 2008. A Group II base oil has greater than or equal to 90 percent saturates and less than or equal to 0.03 percent sulfur and has a VI greater than or equal to 80 and less than 120. A Group III base oil has greater than or equal to 90 percent saturates and less than or equal to 0.03 percent sulfur and has a VI greater than or equal to 120. A Group IV base oil is a polyalphaolefin. The second base oil, for example can be one having a kinematic viscosity at 40°C from 40.00 to 46.00, such as a 220 neutral.

In some embodiments the base oil additionally comprises a second base oil. In one embodiment the base oil contains less than 20 wt%, less than 10 wt% Group III or Group IV base oil, less than 5 wt% Group III or Group IV base oil, or no Group III or Group IV base oil. In another embodiment the base oil contains less than 20 wt%, less than 10 wt%, or no highly paraffinic unconventional base oil. One example of a base oil that can be made without any Group III or Group IV base oil, is base oil having a kinematic viscosity at 40°C from 28.00 to 32.00 mm²/s. This base oil could be referred to as a 150 neutral base oil. This 150 neutral base oil has perfect properties for blending with additives, and even with no other base oils, into engine oils. It can be blended into 10W engine oils that meet modern specifications, including low Noack volatility. Examples of modern specifications that these engine oils can meet are the ACEA 2007 limits for A3/B3, A3/B4, and A5/B5 for gasoline and diesel engine oils.

In one embodiment the base oil can be blended into a 5W grade, a 10W grade, and a 15W grade engine oil without a high amount of Group III or Group IV base oil in the blend. In another embodiment the base oil can be blended into a 5W grade, a 10W grade, and a 15W grade without a high amount of highly paraffinic unconventional base oil. Group III, Group IV, and highly paraffinic unconventional base oils are often considerably more expensive than other Group II base oils. In another embodiment, the 5W, 10W and 15W grades are all multigrade engine oils. In the context of this disclosure, a high amount of Group III or Group IV base oil is considered to be greater than 20 wt%, or in some embodiments a high amount can be greater than 10 wt%. In one embodiment the base oil can be blended into a 5W grade, a 10W grade, and a 15W grade engine oil without any Group III or

Group IV base oil in the blend. In another embodiment the base oil can be blended into a 5W grade, a 10W grade, and a 15W grade engine oil without any highly paraffinic unconventional base oil. 5W, 10W, and 15W grades and multigrade 5W-XX, 10W-XX, and 15W-XX engine oil viscosities are defined
5 by the SAE J300 specification, published November 1, 2007.

Process to Manufacture Base Oil

We provide a process to manufacture a base oil, comprising selecting an original base oil having an original VI from 95 to 115, an original
10 Noack volatility from 20 to 30 wt%, and an original CCS VIS at -25°C from 1100 to 1500 mPa.s. We remove a lower boiling fraction from the original base oil, whereby a base oil is made having a kinematic viscosity at 100°C from 4.2 to 4.6 mm²/s, a VI that is at least 4 higher than the original VI, a Noack volatility that is at least 3 wt% lower than the original Noack volatility,
15 and a CCS VIS at -25°C that is within 200 mPa.s of the original CCS VIS at -25°C.

In one embodiment, the base oil has a ratio of Noack volatility to CCS VIS at -25°C multiplied by 100 within a desired range. The desired range may be from 0.80 to 1.55, from 0.90 to 1.40, from 0.90 to 1.30, or from
20 1.0 to 1.30.

In one embodiment, the original base oil has an original kinematic viscosity at 100°C from 3.75 to 4.45 mm²/s. When the lower boiling fraction is removed this raises the kinematic viscosity of the base oil. In one embodiment the base oil has a kinematic viscosity at 100°C from 4.05 to
25 4.75 mm²/s.

In one embodiment the lower boiling fraction is all of the hydrocarbons in the original base oil boiling below a certain temperature, such as for example 625°F, 650°F, 655°F, or 660°F. The lower boiling fraction is removed by carefully controlled vacuum distillation having a tower top
30 temperature, a tower bottom temperature, a tower top pressure and a tower bottom pressure that are selected to remove all of the hydrocarbons in the original base oil boiling below the certain temperature. Various different types of vacuum distillation control systems may be employed, such as those taught

in U.S. Pat. Nos. 3,365,386, 4,617,092, or 4,894,145; in order to provide the highest yields of desired fractions and exact cut points.

In one embodiment the VI of the base oil is at least 5 higher than the original VI of the original base oil. For example, in this embodiment if the
5 original VI is 105, the VI of the base oil is at least 110. The VI of the base oil is less than 120, such that the base oil is a Group II base oil. In one embodiment, the base oil has a VI from 105 to 119, or 105 to 115.

The Noack volatility of the base oil is at least 3 wt% lower, and up to 20 wt% lower, than the original Noack volatility of the original base oil. In one
10 embodiment the Noack volatility of the base oil is at least 5 wt% lower than the original Noack volatility. In another embodiment the base oil has a Noack volatility less than 18 wt%.

The CCS VIS at -25°C of the base oil is within 200 mPa.s of the original CCS VIS at -25°C. In one embodiment the CCS VIS at -25°C of the
15 base oil is within 175, 150, or 125 mPa.s of the original CCS VIS at -25°C. In one embodiment the base oil has a CCS VIS at -25°C less than 1500 mPa.s. In another embodiment the base oil has a CCS VIS at -25°C greater than 1100 mPa.s.

In one embodiment the base oil has a boiling range from 700 to 925°F
20 (371 to 496°C).

In one embodiment the base oil is made by a process including the additional step of hydrocracking a heavy hydrocarbon feedstock in a hydrocracking zone to obtain a greater amount of the original base oil. The heavy hydrocarbon feedstock has hydrocarbon molecules with a carbon
25 number of C20+, and has a 5 wt% boiling point greater than 600°F (316°C). Suitable examples of heavy hydrocarbon feedstocks include vacuum gas oil, deoiled vacuum gas oil, slack wax, Fischer-Tropsch derived waxy feed, petroleum wax, high pour point polyalphaolefin, foots oil, normal alpha olefin wax, deoiled wax, microcrystalline wax, and mixtures thereof.

30

HYDROCRACKING

In one embodiment the operating conditions in the hydrocracking zone are those typical of commercial hydrocracking operations. In another

embodiment the operating conditions in the hydrocracking zone are selected to convert a heavy hydrocarbon feedstock to a product slate containing greater than 30 wt% of a waxy intermediate fraction which is upgraded to the original base oil. In different embodiments the operating conditions in the hydrocracking zone can be selected to convert a heavy hydrocarbon feedstock to a product slate containing from greater than 30 wt%, from greater than 32 wt%, or from greater than 34 wt% of a waxy intermediate fraction. In different embodiments the operating conditions in the hydrocracking zone can be selected to convert a heavy hydrocarbon feedstock to a product slate containing less than 60 wt%, less than 50 wt%, less than 40 wt%, or less than 35 wt% of a waxy intermediate fraction. In one embodiment the operating conditions in the hydrocracking zone are selected to convert a heavy hydrocarbon feedstock to a product slate containing from greater than 30 wt% to less than 40 wt% of a waxy intermediate.

15 The original base oil has an original VI from 95 to 115, an original Noack volatility from 20 to 30 wt%, and an original CCS VIS at -25°C from 1100 to 1500 mPa.s. The temperature in the hydrocracking zone will be within the range of from about 500 °F (260 °C) to about 900 °F (480 °C), such as within the range of from about 650 °F (345 °C) to about 800 °F (425 °C). A total pressure above 1000 psig is used. For example the total pressure can be above about 1500 psig, or above about 2000 psig. Although greater maximum pressures have been reported in the literature and may be operable, the maximum practical total pressure generally will not exceed about 3000 psig. Liquid hourly space velocity (LHSV) will usually fall within the range of from about 0.2 to about 5.0, such as from about 0.5 to about 1.5. The supply of hydrogen (both make-up and recycle) is preferably in excess of the stoichiometric amount needed to crack the target molecules and will usually fall within the range of from about 500 to about 20,000 standard cubic feet (SCF) per barrel. In one embodiment the hydrogen will be within the range from about 2000 to about 10,000 SCF per barrel.

30 The catalysts used in the hydrocracking zone are composed of natural and synthetic materials having hydrogenation and dehydrogenation activity. These catalysts are well known in the art and are pre-selected to

crack the target molecules and produce the desired product slate. The hydrocracking catalyst is selected to convert a heavy hydrocarbon feedstock to a product slate containing a commercially significant amount of a waxy intermediate fraction which will be upgraded to the original base oil.

- 5 Exemplary commercial cracking catalysts generally contain a support consisting of alumina, silica, silica-alumina composites, silica-alumina-zirconia composites, silica-alumina-titania composites, acid treated clays, crystalline aluminosilicate zeolitic molecular sieves, such as zeolite A, faujasite, zeolite X, zeolite Y, and various combinations of the above. The
- 10 hydrogenation/dehydrogenation components generally consist of a metal or metal compound of Group VIII or Group VIB of the periodic table of the elements. Metals and their compounds such as, for example, cobalt, nickel, molybdenum, tungsten, platinum, palladium and combinations thereof are known hydrogenation components of hydrocracking catalysts.
- 15 In one embodiment, the upgrading of the waxy intermediate fraction includes the steps of hydroisomerization dewaxing in an isomerization reactor and hydrofinishing in a hydrofinishing reactor. Hydroisomerization dewaxing and hydrofinishing are well known in the art. One example of a suitable upgrading process is described in U.S. Patent No 6,337,010, where the
- 20 isomerization of the waxy intermediate feedstock is carried out at a lower total pressure than the hydrocracking operation.

Base Oil by Process

- We provide a base oil having a kinematic viscosity at 100°C from 4.2 to
- 25 4.6 mm²/s, a VI from 105 to 115, and a Noack volatility less than 18 wt% by a process comprising selecting an original base oil and removing a lower boiling fraction. The original base oil has an original VI from 95 to 115, an original Noack volatility from 20 to 30 wt%, and an original CCS VIS at -25°C from
- 30 1000 to 1500 mPa.s. The base oil properties and processes are the same as described earlier. For example, the original base oil may optionally be made by hydrocracking a heavy hydrocarbon feedstock in a hydrocracking zone, wherein the operating conditions in the hydrocracking zone are selected to convert the heavy hydrocarbon feedstock to a product slate containing

greater than 30 wt% of a waxy intermediate fraction which is upgraded to the original base oil. In another embodiment, the base oil can have a ratio of Noack volatility to CCS VIS at -25°C multiplied by 100 from 0.80 to 1.55, from 0.90 to 1.45, or from 0.95 to 1.35.

5 In one embodiment, the removing is done by selecting a distillation cut point that produces a yield of the base oil that corresponds to a target yield based on a commercial demand for a light neutral base oil. The higher the distillation cut point the lower the yield of light neutral base oil that is produced. This can be an advantage when commercial demand for light
10 neutral base oil is low, yet demand for higher quality base oil is increasing, as it leads to overall better base oil plant profitability. As commercial demand for light neutral base oil changes, the distillation cut point can be selected to meet a new target yield.

In another embodiment, the operating conditions in the hydrocracking
15 zone can also be selected to produce a yield of the base oil that corresponds to the target yield based on commercial demand for light neutral. More severe hydrocracking raises the VI of the waxy intermediate fraction, while cracking more of the waxy intermediate fraction into lower boiling hydrocarbons (some of which will be subsequently distilled out of the original
20 base oil that is produced).

A Method for Predicting a Property of a Base Oil

We provide a method for predicting a property of a base oil that comprises selecting a first base stock and a second base stock. A chart is
25 prepared having a first point that is a first viscometric property under low temperature and a first volatility of the first base stock. The chart also has a second point that is a second viscometric property under low temperature and a second volatility of the second base stock. The first base stock and the second base stock are blended in varying proportions to construct a curve
30 between the first point and the second point on the chart. The curve predicts whether a base oil that is a blend of the first base stock and the second base stock will meet base oil requirements for a finished lubricant. If the curve falls below a point representing the base oil requirements for the finished

lubricants, then the base oil blend of the first base stock and the second base stock are capable of making the finished lubricant. If the curve falls above the point representing the base oil requirements for the finished lubricant, then the correct type of a trim stock is ascertained by a direction and a distance one would need to shift the curve.

In this disclosure the position of the curve as being either 'above' or 'below' is relative to how the chart is drawn. For this description, it is assumed that the chart is drawn with the y-axis having the volatility from low to high as one moves away from the origin of the chart. It is also assumed that the chart is drawn with the x-axis having the viscometric property charted from low to high as one moves away from the origin of the chart.

If the chart is drawn with the y-axis having the volatility from high to low as one moves away from the origin of the chart and with the viscometric property from high to low as one moves away from the origin, then the position of the curve being 'above' in fact means that the curve is on the upper value side for the volatility and the viscometric property rather than visually on the upper side in the chart. If the chart is drawn with the y-axis having the volatility from high to low as one moves away from the origin of the chart and with the viscometric property from high to low as one moves away from the origin of the chart, then the position of the curve being 'below' in fact means that the curve is on the lower value side for the volatility and the viscometric property rather than visually on the lower side in the chart.

In one embodiment the finished lubricant is an engine oil. In some embodiments the finished lubricant is a multigrade engine oil, such as 5W-XX, 10W-XX, or 15W-XX, where XX is selected from the group consisting of 20, 30, 40, 50, and 60.

In one embodiment the first and second viscometric properties under low temperature are CCS VIS at -25°C. In another embodiment the first volatility and the second volatility are Noack volatility.

In one embodiment the curve falls above the point representing the base oil requirements for the finished lubricant, and a trim stock is needed to shift the curve below the point. The trim stock is a base oil that has properties that bring the curve in the correct direction. For example, the trim stock may

be a Group II, a Group III, or a Group IV base oil; as long as it has desired properties that bring the curve in the correct direction. Generally, less of the trim stock is needed the closer the curve is to the point representing the base oil requirements for the finished lubricant.

5 In one embodiment, the first base stock, the second base stock, and the trim stock are all Group II. There can be advantages to using all Group II for reducing formulation costs and for simplifying engine oil qualifications.

For the purposes of this specification and appended claims, unless otherwise indicated, all numbers expressing quantities, percentages or
10 proportions, and other numerical values used in the specification and claims, are to be understood as being modified in all instances by the term "about." Furthermore, all ranges disclosed herein are inclusive of the endpoints and are independently combinable. Whenever a numerical range with a lower limit and an upper limit are disclosed, any number falling within the range is
15 also specifically disclosed.

Any term, abbreviation or shorthand not defined is understood to have the ordinary meaning used by a person skilled in the art at the time the application is filed. The singular forms "a," "an," and "the," include plural references unless expressly and unequivocally limited to one instance.

20 All of the publications, patents and patent applications cited in this application are herein incorporated by reference in their entirety to the same extent as if the disclosure of each individual publication, patent application or patent was specifically and individually indicated to be incorporated by reference in its entirety.

25 This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to make and use the invention. Many modifications of the exemplary embodiments of the invention disclosed above will readily occur to those skilled in the art. Accordingly, the invention is to be construed as including all
30 structure and methods that fall within the scope of the appended claims.

EXAMPLES

Example 1:

Samples of Chevron Neutral Oil 100R were received from the Chevron
 5 Richmond Lubricants Oil Plant. Chevron 110RLV base oils were made by
 vacuum distilling off a lower boiling fraction from the Chevron Neutral Oil
 100R. The distillation cut points were approximately 660 to 670°F. The
 average properties of the Chevron Neutral Oil 100R base oil, and the
 properties of two different Chevron 110RLV base oils are shown below, in

10 Table I:

Table I

Property	110RLV Base Oil	110 RLV Base Oil	100R Base Oil
Viscosity Index	112	118	106
SimDist (Wt%), °F			
0.5	668	661	619
5	713	711	672
10	727	731	691
20	745	751	714
30	760	766	732
40	773	780	748
50	785	793	764
60	797	807	779
70	810	822	795
80	825	840	813
90	844	864	838
95	859	885	857
99.5	907	945	904
Kinematic Vis @100°C, mm ² /s	4.391	4.540	4.041
Noack Volatility, wt%	16.2	14.9	23.2
CCS VIS at -25°C	1367	1414	1233

Property	110RLV Base Oil	110 RLV Base Oil	100R Base Oil
Flash Point, COC, °C	216	211	206
Pour Point, °C	-16	-15	-14
Oxidator BN, hours	25.6	29.1	19.1
Total Aromatics	0.0675	0.0538	0.2264
Noack Volatility / CCS VIS at -25°C X 100	1.19	1.06	1.88

The removal of the low boiling fraction of the Chevron 100R gave improvements in a number of different desired base oil properties, including lowering of the Noack volatility, raising of the flash point, lowering of the pour point, increasing of the oxidation stability, and reducing of the aromatics. Another benefit was that the CCS VIS at -25°C was still maintained well below 1500 mPa.s. Prior to this invention, it had been expected that the removal of the lower boiling fraction would increase the CCS VIS at -25°C to well above 1700 mPa.s.

Example 2:

Others have manufactured base oils having a SUS viscosity at 100°F of approximately 110, otherwise known as 110N base oils. One example is ConocoPhillips 110N. Another example is a "110N" blended with Fischer-Tropsch derived base oil, Chevron 220R, and Ergon Hygold 100. This example is fully described in US Patent Application No. 12/047,887, filed March 13, 2008. Kinematic viscosity in mm²/s at 100°F can be converted to SUS viscosity at 100°F according to the arithmetic and the reference table provided in ASTM D 2161-05.

The properties of these two comparison base oils are shown in Table II.

Table II

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Typical Property	ConocoPhillips 110N	"110N" Example from 12/047,887
Viscosity Index	95	104
Kinematic Vis @100°C, mm ² /s	4.10	4.067
Noack Volatility, wt%	26.5	40.56
CCS VIS at -25°C	1500	1259
Flash Point, COC, °C	199	-
Pour Point, °C	-12	-23
Vol% Distilled at 700°F	14 (Max.)	-
Noack Volatility / CCS VIS at -25°C X 100	1.76	3.22

Example 3:

Blends of 10W-30 multigrade engine oil were made with blends of different base stocks. They were blended to all have approximately the same kinematic viscosity at 100°C. An additive package was selected that was designed to formulate engine oils meeting both API CJ-4 and ACEA E9 heavy duty engine oil specifications.

The composition of these engine oil blends, and their properties, are described in Table III. The "X"s in the table indicate what base stocks were included in each of the blends.

Table III

Base Stocks, wt%		Ref.	Blend 1	Blend 2	Blend 3
Chevron 5R		>40			

Base Stocks, wt%		Ref.	Blend 1	Blend 2	Blend 3
Chevron 110RLV			X	X	X
Chevron 220R		X	X	X	X
Chevron 600R		X	X		
Chevron 7R				<10	
6 cSt Group III Base Stock					<20
Additive Package		X	X	X	X
Properties	Spec.	Measurements			
Viscosity Index		139	140	140	139
Kinematic Vis @100°C, mm ² /s	11.6-12.4	12.0	12.0	12.0	12.0
API Gravity	31(typical)	31.1	30.9	31.0	31.1
Noack Volatility, wt%	13(Max)	12.28	12.55	12.60	12.21
CCS VIS at -25°C	5800-7000	6453	6804	6705	6603
Pour Point, °C	-27(Max)	-34	-36	-35	-35
HTHS, mPa.s	3.4(Min)	3.6	3.6	3.6	3.6
MRV @-30°C, mPa.s	60000(Max)	18657	19974	20781	19234
Yield Stress	Pass	Pass	Pass	Pass	Pass
Scanning Brookfield @ -30°C, mPa.s		18657	33361	32172	29805
Gelation Index	12(Max)	5.4	6.1	6.8	5.6

The Chevron 110RLV gave a technical advantage, in that much lower quantities of the more expensive and highly processed Chevron 5R or
5 Chevron 7R were needed to blend excellent 10W-30 engine oils meeting both API CJ-4 and ACEA E9 heavy duty engine oil specifications. Blend 1 had no Group III base oil or Group IV base oil. Blend 2 had less than 10 wt% Group III or Group IV base oil. Blend 3 had less than 20 wt% Group III or Group IV

base oil. Blends 1, 2, and 3 all contained no highly paraffinic unconventional base oil.

Example 4:

5 The chart shown in FIGURE 1 was prepared by selecting different pairs (having a first base stock and a second base stock) of petroleum derived Chevron base stocks, measuring the CCS VIS at -25°C and the Noack volatility of each base stock and plotting the points (a first point and a second point) on a x-y chart. Blends of the paired Chevron base stocks were
10 made in varying proportions and the CCS VIS at -25°C and the Noack volatility of each of the blends were measured and used to construct a curve connecting the first and second points.

 The chart shown in FIGURE 1 also includes points where current commercial multigrade engine oils were tested for CCS VIS at -25°C and
15 Noack volatility. They tended to cluster into areas on the chart. The area circling the small triangles on the left side of the chart are 5W-XX engine oils, the area circling the small squares in the center of the chart are 10W-XX engine oils, and the area circling the small circles on the right side of the chart are 15W-XX engine oils.

20 In this example, base oil requirements for a 10W engine oil were set having a CCS VIS at -25°C of 2800 and a Noack volatility of 14 wt%. The chart in FIGURE 1 was referred to, and it was found that the curve between Chevron 110RLV base oil and Chevron 220R base oil fell below and close to the point representing the base oil requirements for the 10W engine oil. This
25 gave a good prediction that the 10W engine oil requirements could be met with a blend of only these two base oils, and not requiring any trim stock.

 If it was desired that the engine oil have mostly Chevron 100R and Chevron 220R base oil, then an amount of trim stock would need to be used to meet the same base oil requirements. Based on the chart one would
30 predict that blending in of Chevron 7R trim stock would be a good choice to bring down the Noack volatility of the base oil blend to within the desired range. Based on the chart one would also predict that blending in of

Chevron 5R or Chevron 4R trim stock would be a good choice to bring down the CCS VIS at -25°C of the base oil blend to within the desired range.

Example 5:

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A target point with a CCS VIS at -25°C and Noack volatility of 3342 and 11.73 was selected. This target point defines properties that will meet a 10W-XX grade engine oil specification. This target point was placed on a blend chart. Three different base stocks were selected that have CCS VIS at -25°C and Noack volatilities different from this point, and their CCS VIS at -25°C and Noack volatilities were placed on the chart. This blend chart is demonstrated in FIGURE 2. Curves are drawn between the points defining the CCS VIS at -25°C and the Noack volatility of each of the three base oils. The curves defined a space inside the curves, where the target point was positioned. This blend chart demonstrates that these three base oils can be used to make a base oil blend having approximately the CCS VIS at -25°C and Noack volatility of the target point.

Figure 2 illustrates a blend chart having a first point defined by CCS VIS and Noack volatility of Chevron 100R. The blend chart has a second point defined by the CCS VIS and Noack volatility of Chevron 7R. The blend chart has a third point defined by the CCS VIS and Noack volatility of Chevron 220R. Curves are drawn between the three points to form a ternary blending space. A target point of a CCS VIS of 3350 and a Noack volatility of 11.75 is placed on the chart. This target point is characteristic of a typical 10W-XX finished lubricant product base oil blend. The target point is positioned within the ternary blending space defined by the three curves drawn between the three different points. The blend chart instructs a user as to how much of each of the three base oils may be blended to meet the target point properties.

30 The series of lines constructed between the three edges of the ternary blending space represent three degrees of distance away from each base oil component. For instance, going away from 100R towards the 7R/220R blend

curve, a user will encounter three lines along the way that are specific 75%, 50%, and 25% tie-lines between 100R/220R and 100R/7R blend curves.

The composition of each blend component at the target point is defined as a ratio of distances, namely, the distance from the component point to a perpendicular line through the target point divided by the distance from the component point to the opposite edge of the ternary blending space. For example, the amount of 7R in the base oil blend of 100R/220R/7R would be in between 25% and 50% based on the fact that a perpendicular line through the target lies in between the tie-lines that are composed of 50% (closer) and 25% (further away) 7R. A similar process is done for 100R and 220R such that the sum of these compositions is 100%.

WE CLAIM:

1. A method for predicting a property of a base oil, comprising:
 - a. selecting a first base stock and a second base stock;
 - b. preparing a chart having:
 - 5 i. a first point with a first viscometric property under low temperature and a first volatility of the first base stock;
 - ii. a second point with a second viscometric property under low temperature and a second volatility of the second base stock;
 - c. blending the first base stock and the second base stock in varying
10 proportions to construct a curve between the first point and the second point on the chart; wherein the curve predicts whether a base oil that is a blend of the first base stock and the second base stock will meet base oil requirements for a finished lubricant;
 - d. if the curve falls below a point representing the base oil requirements
15 for the finished lubricant, then the base oil blend of the first base stock and the second base stock are capable of making the finished lubricant;
 - e. if the curve falls above the point representing the base oil requirements for the finished lubricant, then the correct type of a trim stock is
20 ascertained by a direction and a distance one would need to shift the curve.
2. The method of claim 1, wherein the finished lubricant is a multigrade engine oil.
3. The method of claim 2, wherein the multigrade engine oil is a 5W-XX
25 grade, a 10W-XX grade, or a 15W-XX grade, wherein XX is selected from the group consisting of 20, 30, 40, 50, and 60.
4. The method of claim 2, wherein the multigrade engine oil meets an engine oil specification selected from the group of API CJ-4, ACEA E9, or a combination thereof.
- 30 5. The method of claim 1, wherein the first viscometric property under low temperature and the second viscometric property under low temperature are a CCS VIS.
6. The method of claim 5, wherein the CCS VIS is measured at -25°C.

7. The method of claim 1, wherein the first volatility and the second volatility are Noack volatility.
8. The method of claim 1, wherein the first base stock and the second base stock are petroleum derived.
- 5 9. The method of claim 1, wherein the first base stock and the second base stock are a Group II or a Group III.
10. The method of claim 1, wherein the trim stock is a Group II, a Group III or a Group IV.
11. The method of claim 1, wherein the first base stock, the second base stock, and the trim stock are a Group II.
12. A blend chart, comprising:
 - a. a first point defined by a first viscometric property and a first volatility of a first base stock;
 - b. a second point defined by a second viscometric property and a second second volatility of a second base stock;
 - 15 c. a curve drawn between the first point and the second point that predicts a third viscometric property and a third volatility of one or more blends of the first base stock and the second base stock; and
 - d. one or more target ranges enclosing desired values of a fourth viscometric property and a fourth volatility that are required to meet a specification for a finished lubricant; wherein the position of the curve relative to the one or more target ranges predicts whether a blend of the first base stock and the second base stock will meet the specification for the finished lubricant.
- 25 13. The blend chart of claim 12, additionally comprising one or more additional points defined by an additional viscometric property and an additional volatility of one or more other base stocks; and a position of one or more of the additional points instructs a user of the chart how much of the one or more other base stocks may be blended with the blend of the first base stock and the second base stock to meet the specification for the finished lubricant.
- 30 14. The blend chart of claim 12, wherein the first, second, third, and fourth viscometric properties are CCS VIS.

15. The blend chart of claim 12, wherein the first, second, third, and fourth volatilities are Noack volatility.
 16. The blend chart of claim 12, wherein the finished lubricant is an engine oil.
 17. The blend chart of claim 12, wherein the one or more target ranges
- 5 enclose desired values of CCS VIS and Noack volatility for one or more multigrade engine oils selected from the group of 5W-XX grade, 10W-XX grade, 15W-XX grade, and combinations thereof.