

**Process for Making and Composition of Superior
Lubricant or Lubricant Blendstock**

BACKGROUND OF THE INVENTION

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Olefin oligomers and relatively long chain olefins can be used in the production of high value lubricant components or blendstocks. One problem with the use of olefin oligomers in either of the above uses is that the olefinic double bond can be undesirable. Olefinic double bonds cause problems in both fuels and in lubricants. Olefin oligomers can further oligomerize forming 'gum' deposits in the fuel. Olefins in fuel are also associated with air quality problems. Olefins can also oxidize which can be a particular problem in lubricants. One way of minimizing the problem is to hydrogenate some or all of the double bonds to form saturated hydrocarbons. A method of doing this is described in US published Application US 2001/0001804 which is incorporated herein in its entirety. Hydrogenation can be an effective way to minimize the concentration of olefins in the lubricant or fuel however it requires the presence of hydrogen and a hydrogenation catalyst both of which can be expensive. Also excessive hydrogenation can lead to hydrocracking. Hydrocracking can increase as one attempts to hydrogenate the olefins to increasingly lower concentrations. Hydrocracking is generally undesirable as it produces a lower molecular weight material where the goal in oligomerization is to produce a higher molecular weight material. Directionally it would generally be preferred to increase, not decrease the average molecular weight of the material. Thus using the hydrogenation method it is desired to hydrogenate the olefins as thoroughly as possible while minimizing any hydrocracking or hydrodealkylation. This is inherently difficult and tends to be a compromise.

Hydrocracking of a slightly branched hydrocarbon material can also lead to less branching. Cracking tend to be favored at the tertiary and secondary centers. For example a branched hydrocarbon can crack at a secondary center forming two more linear molecules which is also directionally undesirable.

Potentially, Ionic Liquid catalyst systems can be used for the oligomerization of olefins such as normal alpha olefins to make olefin oligomers. A Patent that describes the use of an ionic liquid catalyst to make polyalphaolefins is US 6,395,948 which is incorporated herein by reference in its entirety. A published application that discloses a process for oligomerization of alpha olefins in ionic liquids is EP 791,643.

Ionic Liquid catalyst systems have also been used for isoparaffin – olefin alkylation reactions. Patents that disclose a process for the alkylation of isoparaffins by olefins are US 5,750,455 and US 6,028,024.

It would be desirable to have a process for making a lubricant or lubricant starting materials with low degree of unsaturation (low concentration of double bonds) thus reducing the need for exhaustive hydrogenation while preferably maintaining or more preferably increasing the average molecular weight and branching of the material while also increasing the lubricant properties of the product. The present invention provides a new process and a new composition with just such desired features.

SUMMARY OF THE INVENTION

The present invention provides a process for making a lubricant or lubricant component by the oligomerization of olefins to make olefin oligomers of desired chain length range and by alkylation of the olefin oligomer with an isoparaffin to “cap” (alkylate) at least a portion of the remaining double bonds of the olefin oligomers.

A particular embodiment of the present invention provides a process for making a lubricant or lubricant component, comprising, oligomerizing a feed comprising one or more olefins in an ionic liquid oligomerization zone, at oligomerization conditions, to form an oligomer; alkylating said oligomer in the presence of an isoparaffin, in an ionic liquid alkylation zone, at alkylation conditions, to form an alkylated oligomeric product having a cloud point less than – 50 degrees C, a Viscosity Index of at least 134, and a difference between the T90 and T10 boiling points of at least 225 degrees F by Simulated Distillation (SIMDIST). In a particular embodiment the oligomerization can occur simultaneously with the alkylation (i.e. the oligomerization zone and the

alkylation zone are the same) or the oligomerization and the alkylation can occur in different zones preferably under optimized conditions for each zone.

In another embodiment of the present invention, a lubricant component or base oil is disclosed, comprising, a cloud point of less than -50 degrees C;
5 a Viscosity Index of at least 134; a difference between the T90 and T10 boiling points of at least 300 degrees F by SIMDIST; and a Bromine Number of less than 0.2

Oligomerization of two or more olefin molecules results in the formation of an olefin oligomer that generally comprises a long branched chain molecule
10 with one remaining double bond. The present invention provides a novel way to reduce the concentration of double bonds and at the same time enhance the quality of the desired fuel or lubricant. This invention also reduces the amount of hydrofinishing that is needed to achieve a desired product with low olefin concentration. The olefin concentration can be determined by Bromine Index or Bromine Number. Bromine Number can be determined by test ASTM D
15 1159. Bromine Index can be determined by ASTM D 2710. Test methods D 1159 and ASTM D 2710 are incorporated herein by reference in their entirety. Bromine Index is effectively the number of milligrams of Bromine (Br_2) that react with 100 grams of sample under the conditions of the test. Bromine
20 Number is effectively the number of grams of bromine that will react with 100 grams of specimen under the conditions of the test.

In a preferred embodiment of the present invention, HCl or a component that directly or indirectly supplies protons is added to the reaction mixture. Although not wishing to be limited by theory it is believed that the presence of a
25 Brönsted acid such as HCl greatly enhances the acidity and, thus, the activity of the ionic liquid catalyst system.

Among other factors, the present invention involves a surprising new way of making a lubricant base oil or lubricant blendstock that has reduced levels of olefins without hydrogenation or with minimal hydrofinishing. The
30 present invention also increases the value of the resultant olefin oligomers by increasing the molecular weight of the oligomer and increasing the branching by incorporation of isoparaffin groups into the oligomers' skeletons. These properties can both add significant value to the product particularly when

starting with a highly linear hydrocarbon such as the preferred feeds to the present invention (i.e. Fischer-Tropsch derived hydrocarbons). The product of the present invention can have a combination of highly desirable and novel qualities for a lubricant component or base oil including a very high Viscosity Index with a very low cloud point while having a fairly wide boiling range. The present invention is based on the use of an ionic liquid catalyst to alkylate an oligomerized olefin with an isoparaffin under relatively mild conditions. The alkylation optionally can occur under effectively the same conditions as oligomerization. This finding that alkylation and oligomerization reactions can occur using effectively the same ionic liquid catalyst system and optionally under similar or even the same conditions can be used to make a highly integrated, synergistic process resulting in an alkylated oligomer product having desirable properties. Also in a particular embodiment of the present invention the alkylation and oligomerization reactions can occur simultaneously under the same conditions.

A preferred catalyst system of the present invention is an acidic chloroaluminate ionic liquid system. More preferably the acidic chloroaluminate ionic liquid system is used in the presence of a Brønsted acid. Preferably the Brønsted acid is a halohalide and most preferably is HCl.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a novel process for the production of lubricant or lubricant components by the acid catalyzed oligomerization of olefins and alkylation with isoparaffins in ionic liquid medium to form a product having greatly reduced olefin content and improved quality. Amazingly, we found that oligomerization of an olefin and alkylation of an olefin and/or its oligomers with an isoparaffin can be performed together in a single reaction zone or alternatively in two separate zones. The alkylated or partially alkylated oligomer stream that results has very desirable properties for use as a lubricant or lubricant blendstock. In particular the present invention provides a process for making a lubricant, base oil, lubricant component, or solvent having improved properties such as increased branched, higher molecular weight, and low

Bromine Number. The present invention also provides a composition of a lubricant component or base oil having improved properties including a cloud point of less than - 55 degrees C; a Viscosity Index of at least 140; a difference between the T90 and T10 boiling points of at least 250 degrees F by SIMDIST; and a Bromine Number of less than 0.2.

As mentioned the oligomerization reaction and the alkylation reaction in the present invention can be performed together or separately. An advantage of combining the oligomerization and alkylation is lower capital and operating costs. An advantage of the 2 step process (oligomerization followed by alkylation in a separate zone) is that the two separate reaction zones can be optimized independently. Thus the conditions for oligomerization zones can be different than the alkylation zone conditions. Also the ionic liquid catalyst can be different in the different zones. For instance, it may be preferable to make the alkylation zone more acidic than the oligomerization zone. This may involve the use of an entirely different ionic liquid catalyst in the two zones or can be by addition of a Brönsted acid to the alkylation zone.

In a preferred embodiment of the present invention, the ionic liquid used in alkylation zone and in the oligomerization zone is the same. This helps save on catalyst costs, potential contamination issues, and provides synergy opportunities in the process.

As discussed above, the present invention produces a product having a very low cloud point and a very high Viscosity Index (VI). Cloud Point can be determined by ASTM D 2500. Viscosity Index can be determined by ASTM D 2270. ASTM test methods D 2500 and D D2270 are incorporated by reference herein in their entirety.

In the present application, distillation data was generated for several of the products by SIMDIST. Simulated Distillation (SIMDIST) involves the use of ASTM D 6352 or ASTM D 2887 as appropriate. ASTM D 6352 and ASTM D 2887 are incorporated herein by reference in their entirety. Distillation data can also be generated using ASTM D86 which is incorporated herein by reference in its entirety.

In the present application the terms lubricant base oil, lubricant blendstock, and lubricant component are used to mean lubricant components that can be used to produce a finished lubricant.

5 Ionic Liquids

Ionic liquids are a class of compounds made up entirely of ions and are generally liquids at ambient and near ambient temperatures. Often salts which are composed entirely of ions are solids with high melting points, for example, above 450 degrees C. These solids are commonly known as 'molten salts' when heated to above their melting points. Sodium chloride, for example, is a common 'molten salt', with a melting point of 800 degree C. Ionic liquids differ from 'molten salts', in that they have low melting points, for example, from -100 degrees C to 200 degree C. Ionic liquids tend to be liquids over a very wide temperature range, with some having a liquid range of up to 300 degrees C or higher. Ionic liquids are generally non-volatile, with effectively no vapor pressure. Many are air and water stable, and can be good solvents for a wide variety of inorganic, organic, and polymeric materials.

The properties of ionic liquids can be tailored by varying the cation and anion pairing. Ionic liquids and some of their commercial applications are described, for example, in J. Chem. Tech. Biotechnol, 68:351-356 (1997); J. Phys. Condensed Matter, 5:(supp 34B):B99-B106 (1993); Chemical and Engineering News, Mar. 30, 1998, 32-37; J. Mater. Chem., *:2627-2636 (1998); and Chem. Rev., 99:2071-2084 (1999), the contents of which are hereby incorporated by reference.

Many ionic liquids are amine-based. Among the most common ionic liquids are those formed by reacting a nitrogen-containing heterocyclic ring (cyclic amines), preferably nitrogen-containing aromatic rings (aromatic amines), with an alkylating agent (for example, an alkyl halide) to form a quaternary ammonium salt, followed by ion exchange with Lewis acids or halide salts, or by anionic metathesis reactions with the appropriate anion sources to introduce the desired counter anionic to form ionic liquids. Examples of suitable heteroaromatic rings include pyridine and its derivatives, imidazole and its derivatives, and pyrrole and its derivatives. These rings can

be alkylated with varying alkylating agents to incorporate a broad range of alkyl groups on the nitrogen including straight, branched or cyclic C₁₋₂₀ alkyl group, but preferably C₁₋₁₂ alkyl groups since alkyl groups larger than C₁-C₁₂ may produce undesirable solid products rather than ionic liquids. Pyridinium and
5 imidazolium-based ionic liquids are perhaps the most commonly used ionic liquids. Other amine-based ionic liquids including cyclic and non-cyclic quaternary ammonium salts are frequently used. Phosphonium and sulphonium-based ionic liquids have also been used.

Counter anions which have been used include chloroaluminate,
10 bromoaluminate, gallium chloride, tetrafluoroborate, tetrachloroborate, hexafluorophosphate, nitrate, trifluoromethane sulfonate, methylsulfonate, p-toluenesulfonate, hexafluoroantimonate, hexafluoroarsenate, tetrachloroaluminate, tetrabromoaluminate, perchlorate, hydroxide anion, copper dichloride anion, iron trichloride anion, antimony hexafluoride, copper
15 dichloride anion, zinc trichloride anion, as well as various lanthanum, potassium, lithium, nickel, cobalt, manganese, and other metal ions. The ionic liquids used in the present invention are preferably acidic haloaluminates and preferably chloroaluminates.

The organic cations in the ionic liquid of the present invention can be selected
20 from the group consisting of pyridinium-based and imidazolium-based cations. Cations that have been found to be particularly useful in the process of the present invention include pyridinium-based cations.

Preferred ionic liquids that can be used in the process of the present invention include acidic chloroaluminate ionic liquids. Preferred ionic liquids used in the
25 present invention are acidic pyridinium chloroaluminates. More preferred ionic liquids useful in the process of the present invention are alkyl-pyridinium chloroaluminates. Still more preferred ionic liquids useful in the process of the present invention are alkyl-pyridinium chloroaluminates having a single linear alkyl group of 2 to 6 carbon atoms in length. One particular ionic liquid that has
30 proven effective is 1-butyl-pyridinium chloroaluminate.

In a more preferred embodiment of the present invention 1-butyl-pyridinium chloroaluminate is used in the presence of a Brönsted acid. Not to be limited by theory, the Brönsted acid acts as a promoter or co-catalyst. Examples of

Brönsted acids are Sulfuric, HCl, HBr, HF, Phosphoric, HI, etc. Other protic acids or species that directly or indirectly aid in supplying protons may also be used as Bronsted acids or in place of Brönsted acids.

5 The Feeds

In the process of the present invention one of the important feedstocks comprises a reactive olefinic hydrocarbon. The olefinic group provides the reactive site for the oligomerization reaction as well as the alkylation reaction. The olefinic hydrocarbon can be a fairly pure olefinic hydrocarbon cut or can be a
10 mixture of hydrocarbons having different chain lengths thus a wide boiling range. The olefinic hydrocarbon can be terminal olefin (an alpha olefin) or can be internal olefin (internal double bond). The olefinic hydrocarbon chain can be either straight chain or branched or a mixture of both. The feedstocks useable in the present invention can include unreactive diluents such as normal paraffins.

15 In one embodiment of the present invention, the olefinic feed comprises a mixture of mostly linear olefins from C₂ to about C₃₀. The olefins are mostly but not entirely alpha olefins.

In another embodiment of the present invention, the olefinic feed can comprise at least 50 % of a single alpha olefin species.

20 In another embodiment of the present invention, the olefinic feed can be comprised of an NAO cut from a high purity Normal Alpha Olefin (NAO) process made by ethylene oligomerization.

In an embodiment of the present invention, some or all of the olefinic feed to the process of the present invention comprises thermally cracked hydrocarbons, preferably cracked wax, and more preferably cracked wax from a Fischer-Tropsch (FT) process. A process for making olefins by cracking FT products is disclosed in US Patent 6,497,812 which is incorporated herein by reference in its
25 entirety.

In the process of the present invention, another important feedstock is an
30 isoparaffin. The simplest isoparaffin is isobutane. Isopentanes, isohexanes, isoheptanes, and other higher isoparaffins are also useable in the process of the present invention. Economics and availability are the main drivers of the isoparaffins selection. Lighter isoparaffins tend to be less expensive and more

available due to their low gasoline blend value (due to their relatively high vapor pressure). Mixtures of light isoparaffins can also be used in the present invention. Mixtures such as C₄-C₅ isoparaffins can be used and may be advantaged because of reduced separation costs. The isoparaffins feed stream
5 may also contain diluents such as normal paraffins. This can be a cost savings by reducing the cost of separating isoparaffins from close boiling paraffins. Normal paraffins will tend to be unreactive diluents in the process of the present invention.

In an optional embodiment of the present invention the resultant alkylated
10 oligomer made in the present invention can be hydrogenated to further decrease the concentration of olefins and thus the Bromine Number. After hydrogenation the lubricant component or base oil has a Bromine Number of less than 0.8, preferably less than 0.5, more preferably less than 0.3, still more preferably less than 0.2.

15 Alkylation conditions for the process of the present invention include a temperature of from about 15 to about 200 degrees C, preferably from about 20 to about 150 degrees C, more preferably from about 25 to about 100, and most preferably from 50 to 100 degrees C.

Oligomerization conditions for the process of the present invention include
20 a temperature of from about 0 to about 150 degrees C, preferably from about 10 to about 100 degrees C, more preferably from about 0 to about 50.

As discussed elsewhere in the present application the oligomerization and the alkylation can occur separately (in separate optimized zones) or can occur together. In the embodiment where the alkylation and oligomerization occur
25 together, optimum conditions for either reaction may have to be compromised. However, surprisingly the conditions can be adjusted to achieve both substantial oligomerization and alkylation and resulting in a valuable lubricant base oil or blendstock.

In summary, the potential benefits of the process and composition of the
30 present invention include:

- Reduced capital cost for hydrotreating/hydrofinishing

- Lower operating cost due to reduced hydrogen and extensive hydrogenation requirements
- Potential use of the same ionic liquid catalyst for oligomerization and alkylation steps
- 5 • Improved branching characteristics of the product
- Increased overall molecular weight of the product
- Incorporation of low cost feed (isoparaffins) to increase liquid yield of high value distillate fuel or lubricant components
- 10 • Production of a base oil or lubricant component having unique, high value properties

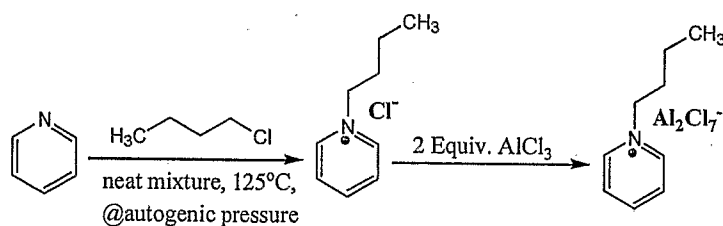
EXAMPLES

Example 1:

Preparation of Fresh 1-Butyl-pyridinium Chloroaluminate Ionic Liquid

15 1-butyl-pyridinium chloroaluminate is a room temperature ionic liquid prepared by mixing *neat* 1-butyl-pyridinium chloride (a solid) with *neat* solid aluminum trichloride in an inert atmosphere. The syntheses of 1-butyl-pyridinium chloride and the corresponding 1-butyl-pyridinium chloroaluminate are described below. In a 2-L Teflon-lined autoclave, 400 gm (5.05 mol.) anhydrous pyridine (99.9%
20 pure purchased from Aldrich) were mixed with 650 gm (7 mol.) 1-chlorobutane (99.5% pure purchased from Aldrich). The neat mixture was sealed and let to stir at 125°C under autogenic pressure over night. After cooling off the autoclave and venting it, the reaction mix was diluted and dissolved in chloroform and transferred to a three liter round bottom flask. Concentration of
25 the reaction mixture at reduced pressure on a rotary evaporator (in a hot water bath) to remove excess chloride, un-reacted pyridine and the chloroform solvent gave a tan solid product. Purification of the product was done by dissolving the obtained solids in hot acetone and precipitating the pure product through cooling and addition of diethyl ether. Filtering and drying under
30 vacuum and heat on a rotary evaporator gave 750 gm (88% yields) of the desired product as an off-white shinny solid. ¹H-NMR and ¹³C-NMR were ideal for the desired 1-butyl-pyridinium chloride and no presence of impurities was observed by NMR analysis.

1-Butyl-pyridinium chloroaluminate was prepared by slowly mixing dried 1-butyl-pyridinium chloride and anhydrous aluminum chloride (AlCl_3) according to the following procedure. The 1-butyl-pyridinium chloride (prepared as described above) was dried under vacuum at 80°C for 48 hours to get rid of residual water (1-butyl-pyridinium chloride is hygroscopic and readily absorbs water from exposure to air). Five hundred grams (2.91 mol.) of the dried 1-butyl-pyridinium chloride were transferred to a 2-Liter beaker in a nitrogen atmosphere in a glove box. Then, 777.4 gm (5.83 mol.) of anhydrous powdered AlCl_3 (99.99% from Aldrich) were added in small portions (while stirring) to control the temperature of the highly exothermic reaction. Once all the AlCl_3 was added, the resulting amber-looking liquid was left to gently stir overnight in the glove box. The liquid was then filtered to remove any un-dissolved AlCl_3 . The resulting acidic 1-butyl-pyridinium chloroaluminate was used as the catalyst for the Examples in the Present Application.



Example 2

Oligomerization of 1-Decene

One process for making high quality oils is by oligomerization of olefins followed in a separate step by alkylation with an isoparaffin. Olefin oligomers exhibit good physical lubricating properties. However, introducing short chain branching in the oligomers enhances the properties of the final products. Introducing the branching can be done by alkylation of the oligomers with isoparaffins. Alkylation of the oligomeric products is also a route to reducing the olefinicity of the oligomers and, hence, producing chemically and thermally more stable oligomers. The process is exemplified by alkylation of 1-decene oligomers (described below).

Oligomerization of 1-decene and alkylation of the oligomer were done according to the procedures described below. In a 300 cc autoclave equipped with an overhead stirrer, 100 gm of 1-decene was mixed in with 20 gm of 1-methyl-tributyl ammonium chloroaluminate. A small amount of HCl (0.35 gm) was introduced to the mix as a promoter and the reaction mix was heated to 50°C with vigorous stirring for 1 hr. Then, the stirring was stopped and the reaction was cooled down to room temperature and let to settle. The organic layer (insoluble in the ionic liquid) was decanted off and washed with 0.1N KOH. The organic layer was separated and dried over anhydrous MgSO₄. The colorless oily substance was analyzed by SIMDIST. The oligomeric product has a Bromine Number of 7.9. Table 1 below shows the SIMDIST analysis of the oligomerization products.

Example 3

Alkylations of 1-Decene Oligomers

The oligomers of 1-decene made as described in example 2 were alkylated with isobutane in 1-butylpyridinium chloroaluminate and in methyl-tributyl ammonium chloroaluminate (TBMA) ionic liquids according to the procedures described below. In a 300 cc autoclave fitted with an overhead stirrer, 26 gm of the oligomer and 102 gm of isobutane were added to 21 gm of methyl-tributyl-ammonium chloroaluminate ionic liquid. To this mixture, 0.3 gm of HCl gas was added and the reaction was heated to 50°C for 1 hr while stirring at >1000 rpm. Then the reaction was stopped and the products were collected in a similar procedure as described above for the oligomerization reaction. The collected products, colorless oils, have Bromine Number of 3.2. Table 1 shows the SIMDIST analysis of the oligomer alkylation products.

Alkylation of the oligomer was repeated using the same procedure described above, but 1-butylpyridinium chloroaluminate was used in place of methyl-tributyl-ammonium chloroaluminate. Alkylation of the oligomer in butylpyridinium gave a product with a bromine index of 2.7. The SIMDIST data is shown in Table 1.

Table 1

SIMDIST TBP (WT%)	1-Decene Oligomers °F	1-Decene oligomers Alkylation in 1- butylpyridinium chloroaluminate	1-Decene oligomers alkylation in TBMA
TBP@0.5	330	298	296
TBP@5	608	341	350
TBP@10	764	574	541
TBP@15	789	644	630
TBP@20	856	780	756
TBP@30	944	876	854
TBP@40	1018	970	960
TBP@50	1053	1051	1050
TBP@60	1140	1114	1118
TBP@70	1192	1167	1173
TBP@80	1250	1213	1220
TBP@90	1311	1263	1268
TBP@95	1340	1287	1291
TBP@99.5	1371	1312	1315

Example 4

5 **Oligomerization of 1-Decene in Ionic Liquids in the Presence of iso-Butane**

10 Oligomerization of 1-decene was carried out in acidic 1-butyl-pyridinium chloroaluminate in the presence of 10 mole% of isobutane. The reaction was done in the presence of HCl as a promoter. The procedure below describes, in general, the process. To 42 gm of 1-butyl-pyridinium chloroaluminate in a 300 cc autoclave fitted to an overhead stirrer, 101 gm of 1-decene and 4.6 gm of isobutane were added and the autoclave was sealed. Then 0.4 gm of HCl was introduced and the stirring started. The reaction was heated to 50 °C. The

reaction was exothermic and the temperature quickly jumped to 88 °C. The temperature in few minutes went back down to 44 °C and was brought up to 50 °C and the reaction was vigorously stirred at about 1200 rpm for an hour at the autogenic pressure (~atmospheric pressure in this case). Then, the stirring
5 was stopped and the reaction was cooled to room temperature. The contents were allowed to settle and the organic layer (immiscible in the ionic liquid) was decanted off and washed with 0.1N KOH aqueous solution. The colorless oil was analyzed with simulated distillation and bromine analysis. The Bromine Number was 2.6. The Bromine Number is much less than that usually
10 observed for the 1-decene oligomerization in the absence of isobutane. The Bromine Number for 1-decene oligomerization in the absence of iC_4 is in the range of 7.5-7.9 based on the catalyst, contact time and catalyst amounts used in the oligomerization reaction. The Simulated Distillation data is shown in Table 3.

15 The Simulated Distillation data in Tables 1 and 3 show that alkylations of the already made 1-decene oligomers with isobutane and the simultaneous oligomerization/alkylation of 1-decene lead to fairly comparable products. The overall outcome of the two operations is amazingly close in the products boiling
20 ranges and olefinic contents as indicated by bromine numbers shown in Table 2.

Table 2 compares the Bromine Numbers of the starting 1-decene, 1-decene oligomerization products in the presence of iC_4 , 1-decene oligomerization
25 products without iC_4 , and the alkylation products of 1-decene oligomers with excess iC_4 .

Table 2

Material	1-Decene	Oligomerization-alkylation of 1-Decene with 10 mol% iC ₄	Oligomerization Products of 1-Decene/No iC ₄	Alkylated 1-decene oligomers
Bromine Number	114	2.6	7.9	2.8

- 5 The data above suggests that the chemistry can be done by either alkylating the oligomers in situ (where isoparaffins are introduced into the oligomerization reactor) or in consecutive step to oligomerization of an alpha olefin. In both processes, the yielded products are close in their properties. In the simultaneous oligomerization-alkylation scheme, the desired alkylated
- 10 oligomeric products can be made in one single step and, thus, can be economically advantageous process. However, the two step process with two separate reaction zones where each can be optimized independently, provides greater chances for tailoring and tuning the conditions to make products with particularly desired properties.

15

Example 5:**Oligomerization of 1-Decene in Ionic Liquids in the Presence of varying iso-Butane Concentrations**

- 20 Oligomerization of 1-decene was carried out in acidic 1-butyl-pyridinium chloroaluminate in the presence of varying mole% of isobutane. The reaction was done in the presence of HCl as a promoter (co-catalyst). The procedure below describes, in general, the process. To 42 gm of 1-butyl-pyridinium chloroaluminate in a 300 cc autoclave fitted to an overhead stirrer, 101 gm of 1-
- 25 decene and 4.6 gm of isobutane were added and the autoclave was sealed. Then 0.2-0.5 gm of HCl was introduced into the reactor, and then, started the stirring. The reaction is exothermic and the temperature quickly jumped to

- 88°C. The temperature dropped down quickly to the mid 40s and was brought up to 50 °C and kept at around 50°C for the remainder of the reaction time. The reaction was vigorously stirred for about an hour at the autogenic pressure. The stirring was stopped, and the reaction was cooled to room temperature.
- 5 The contents were allowed to settle and the organic layer (immiscible in the ionic liquid) was decanted off and washed with 0.1N KOH aqueous solution. The recovered oils were characterized with simulated distillation, bromine analysis, viscosity, viscosity indices, and pour and cloud points.
- 10 Table 3 below show the properties of the resulting oils of different 1-decene/isobutane ratios. All the reactions were run for approximately 1 hr at 50 degrees C in the presence of 20 gm of ionic liquid catalyst.

Table 3

n	C ₁₀ =/iC ₄ =0.8	C ₁₀ =/iC ₄ =1	C ₁₀ =/iC ₄ =4	C ₁₀ =/iC ₄ =5.5	C ₁₀ =/iC ₄ =9
TBP @0.5	301	311	322	329	331
TBP @5	340	382	539	605	611
TBP @10	440	453	663	746	775
TBP @20	612	683	792	836	896
TBP @30	798	842	894	928	986
TBP @40	931	970	963	999	1054
TBP @50	1031	1041	1007	1059	1105
TBP @60	1098	1099	1067	1107	1148
TBP @70	1155	1154	1120	1154	1187
TBP @80	1206	1205	1176	1200	1228
TBP @90	1258	1260	1242	1252	1278
TBP @95	1284	1290	1281	1282	1305
TBP @99.5	1311	1326	1324	1313	1335

15

- The data shown in Table 3 indicate that the amount of isobutane added to the reaction does influence the boiling range of the produced oils. As shown in the in Table 3, there are more in the lower boiling cuts at higher concentration of isobutane in the reaction. This indicates that more alkylation is taking part
- 5 directly with 1-decene and 1-decene dimers rather than with higher oligomers when higher isobutane concentrations are present in the reaction zone. When more isobutane is present more alkylation can occur, and 1-decene alkylation with iC_4 to make C_{14} and 1-decene dimer alkylation to make C_{24} will be more prevalent than at lower concentrations of isobutane. Therefore, the degree of
- 10 branching and oligomerization can be tailored by the choice of olefins, isoparaffins, olefin/isoparaffin ratios, contact time and the reaction conditions. The alkylated oligomers will no longer take part in further oligomerization due to "capping" off their olefinic sites, and the final oligomeric chain will be shorter perhaps than the normal oligomeric products but with more branching.
- 15 While the oligomerization pathway is the dominant mechanism, it is very clear that the alkylation of 1-decene and its oligomers with isobutane does take part in the chemistry.

- Table 4 below compares some physical properties of the products obtained
- 20 from the reactions of Table 3

Table 4

	$C_{10}/iC_4=0.8$	$C_{10}/iC_4=1$	$C_{10}/iC_4=4$	$C_{10}/iC_4=5.5$	$C_{10}/iC_4=9$
VI	145	171	148	190	150
Vis@100	9.84	7.507	9.73	7.27	11.14
VIS@40	61.27	37.7	59.63	33.5	70.21
Pour Point	-42	-42		-44	-52
Cloud Point	-63	-64		-69	-28
Bromine Number	3.1	0.79	2.2	3.8	6.1

The oligomerization/alkylation run @ 1-decene/iC₄ ratio of 5.5 was repeated several times at the same feed ratios and conditions. The viscosity@100 in the repeated samples ranged from 6.9-11.2. The VI ranged from 156-172. All the repeated samples contained low boiling cuts (below 775 degrees F) ranging from 10%-15%. The low boiling cut appears to influence the VI.

The Bromine Numbers shown in Table 4 are much less than usually observed for the 1-decene oligomerization in the absence of isobutane. The Bromine Number for 1-decene oligomerization in the absence of iC₄ is in the range of 7.5-7.9 based on the catalyst, contact time and catalyst amounts used in the oligomerization reaction. Table 5 below compares the Bromine Number analysis of 1-decene, simultaneous oligomerization and alkylation of 1-decene, 1-decene oligomerization only products, and the alkylated oligomers (oligomerization followed by alkylation). By looking at these values, one can see the role of the incorporation of isobutane on the olefinicity of the final products.

Table 5

Material	1-Decene	Oligomerization with 10 mol% iC ₄ , (20 mol% iC ₄)	1-Decene Oligomerization	Alkylated 1-decene oligomers with iC ₄
Bromine Number	114	6.1, (2.2)	7.9	2.8

Example 6:

Oligomerization of a Mixture of Alpha Olefins in the Presence of iso-Butane

A 1:1:1 mixture of 1-hexene:1-octene:1-decene was oligomerised in the presence of isobutane at the reaction conditions described earlier for oligomerization of 1-decene in the presence of isobutane (100 gm olefins, 20 gm IL catalyst, 0.25 gm HCl as co-catalyst, 50°C, autogenic pressure, 1hr). The products were separated from the IL catalyst, and the IL layer was rinsed with hexane, which was decanted off and added to the products. The products

and the hexane wash were treated with 0.1N NaOH to remove any residual AlCl_3 . The organic layers were collected and dried over anhydrous MgSO_4 . Concentration (on a rotary evaporator at reduced pressure, in a water bath at ~70 degrees C) gave the oligomeric product as viscous yellow oils. Table 6 below shows the Simulated Distillation, viscosity, and pour point, cloud point, and bromine number data of the alkylated oligomeric products of the olefinic mixture in the presence of isobutane.

Table 6

SIMDIST TBP (WT%),	Oligomers of $\text{C}_6^=, \text{C}_8^=, \text{C}_{10}^=$ W/ iC ₄ °F
TBP @0.5	313
TBP @5	450
TBP @10	599
TBP @15	734
TBP @20	831
TBP @30	953
TBP @40	1033
TBP @50	1096
TBP @60	1157
TBP @70	1220
TBP @80	1284
TBP @90	1332
TBP @95	1357
TBP @99.5	1384
Physical Properties:	
VI	140
VIS@100	7.34 CST
VIS@40	42 CST
Pour Point	-54 °C
Cloud Point	<-52 °C
Bromine #	3.1

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As shown in the data above, high quality oils with desirable lubricating properties can be made by either simultaneous olefin oligomerization/alkylation, or by oligomerization of the appropriate olefins followed by alkylation of the oligomeric products. Regardless of the process, the oils produced in both processes appear to be close in their boiling ranges, olefinicity and physical

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properties such as viscosity indices, viscosities, pour points and cloud points. Both process lead to oils with appreciable concentrations of branched paraffins formed by capping (alkylating) olefins and their oligomers and low olefin concentrations.

What is claimed is:

1. A process for making a lubricant or lubricant component, comprising:
5 oligomerizing a feed comprising one or more olefins in an ionic liquid
oligomerization zone, at oligomerization conditions, to form an oligomer;
alkylating said oligomer in the presence of an isoparaffin, in an ionic
liquid alkylation zone, at alkylation conditions, to form an alkylated
oligomeric product having a cloud point less than -50 degrees C, a
Viscosity Index of at least 134, and a difference between the T90 and
10 T10 boiling points of at least 225 degrees F by SIMDIST.
2. The process of claim 1 wherein the ionic liquid alkylation zone further
comprises a Brönsted acid.
- 15 3. A lubricant component or base oil, comprising:
a cloud point of less than -50 degrees C;
a Viscosity Index of at least 134;
a difference between the T90 and T10 boiling points of at least 300
degrees F by SIMDIST; and
20 a Bromine Number of less than 0.2.
4. The lubricant component or base oil of claim 3 wherein the Viscosity
Index is at least 145.
- 25 5. The process of claim 1 wherein the mole ratio of oligomer to isoparaffin
is at least 0.5.
6. The process of claim 1 wherein said alkylated oligomeric product has a
Bromine Number of less than 2.7.
- 30 7. A process of claim 1 wherein the alkylated oligomeric product has a
TBP@50 of at least 1000 degrees F by SIMDIST and a Bromine
Number of less than 4.

8. The process of claim 1 wherein said alkylated oligomeric product has a Bromine Number of less than 3.
- 5 9. The process of claim 1 wherein the isoparaffin is selected from the group consisting of isobutane, isopentane, and a mixture comprising isobutane and isopentane.
- 10 10. The process of claim 1 wherein the alkylated oligomeric product is subjected to hydrogenation to produce a low olefin lubricant base oil.
11. The process of claim 10 wherein said low olefin lubricant base oil has a Bromine Number of less than 0.2 by ASTM D 1159.
- 15 12. The process of claim 1 wherein the feed stream comprising one or more olefins comprises at least one alpha olefin.
13. The process of claim 1 wherein the feed stream comprising one or more olefins comprises at least 50 mole % of a single alpha olefin species.
- 20 14. The process of claim 1 wherein the feed stream comprising one or more olefins comprises a mixture of alpha olefins.
15. The process of claim 1 wherein the alkylated oligomeric product is subjected to hydrogenation to form a low olefin content alkylated oligomer.
- 25 16. The process of claim 15 wherein the low olefin content alkylated oligomer has a Bromine Number of less than 0.2 as measured by ASTM D 1159.
- 30 17. The process of claim 1 wherein the ionic liquid oligomerization zone comprises an acid chloroaluminate ionic liquid catalyst.

18. The process of claim 1 wherein the ionic liquid oligomerization zone and the ionic liquid alkylation zone comprise a different ionic liquid catalyst.
- 5 19. The process of claim 1 wherein the ionic liquid oligomerization zone and the ionic liquid alkylation zone comprise the same ionic liquid catalyst.
20. The process of claim 1 wherein the ionic liquid alkylation zone and the ionic liquid oligomerization zone are the same zone.

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