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Applications of High-Quality Base Oil to Specialty Lubricants

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Abstract: There have been significant improvements in base oil quality in order to satisfy recent market needs. In particular, requirements of passenger car motor oils have been leading the trend. Now, high quality base oils such as VHVI base oils and PAOs are to be formulated in order to meet the tight volatility specifications. The severe hydrocracking, hydro-isomerized dewaxing and hydro-finishing process with noble-metal based catalysts (named UCO lube process) developed by SK corporation has been introduced as one of economic hydroprocessing routes to produce high quality VHVI base oils and food grade white mineral oils from fuels hydrocracker residue. Product quality of UCO lube process is similar to PAO in general performances and therefore provides satisfactory performance for all straightforward applications in general lubricants. However, when applied to specialty lubricants like transformer oils, spray oils and coning oils, severely hydrocracked base oils are known to have various compatibility problems with gas or surfactants formulated in them. These problems are related to the difference in their composition; inherent high paraffin contents and lack of dissolving ability. Fortunately, it was found that excellent specialty lubricants could be made by carefully selecting and formulating adequate additives and/or aromatic compounds. Moreover, these specialties with high quality VHVI base oils offer various advantages over conventional base oil based products.

Keywords: Base oil, group III, speciality lubricants, spray oils, white oils

Introduction

Todays lubricants market needs have lead to an increased use of high quality base oils like high viscosity index API Group II, Group III base oils and PAOs. In the automotive lubricants industry, these base oils are used to overcome the tightened market requirements like fuel economy, low temperature performance and volatility. The ILSAC GF-3 specification is also expected to increase the demand for high quality base oils.

In order to reduce the high cost to satisfy recent market requirements, the use of severely hydrocracked base oils may be beneficial, as their price is expected to go down due to their rapidly increasing availability. SK Corporation started producing VHVI base oils from fuels hydrocracker bottom oils in 1995 and has recently improved their quality and produces food grade white mineral oils.

With their availability rapidly increasing, high quality base oils are expanding their applications to industrial lubricating oils and specialties. When these base oils are applied to specialty lubricants like agricultural spray oils, coning oils, transformer oils, etc., better performances can be expected.

More paraffin content of severe hydrocracking base oils compared to conventional base oils provides better electrical properties in transformer oils and better compatibility with plant leaves in agricultural spray oils. The light stability, oxidation stability and high lubricity of these base oils are beneficial to application in textile lubricants.

However, the more paraffinic nature limits their applications to specialty lubricant area because of their low dissolving power. This problem can be solved through careful selection of additives and/or formulation of adequate aromatic compounds.

High quality base oils and white mineral oils from fuels hydrocracker residue

There are several approaches to producing high quality lubricant base oils, high viscosity index API Group base oils and VHVI Group base oils. Generally, high quality base oils are produced by severe hydro-cracking of vacuum distillate fractions in the hydrocracker.

SK Corporation has developed commercial facility, which we call UCO (unconverted oil) lube process to produce high quality VHVI base oils from fuels hydrocracker residue at SKs Ulsan refinery in October 1995 and produces 3,500 bpd of high viscosity index API Group base oils and VHVI base oils. The downstream dewaxing technology used to be a cracking type catalyst process. In order to improve dewaxed oil yield and quality, the catalyst was replaced with a new isomerization type dewaxing catalyst in June 1997.

Recently, SKs UCO lube process has been developed the catalytic hydrogenation in hydro-finishing process. The objective of the development of the UCO lube process was to accomplish the production of food grade white mineral oils as well as the high quality lube base oils from the fuels hydrocracker residue efficiently. To achieve these targets optimally, a system of catalyst and process conditions has been

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Table 1. Catalysts and operating conditions of hydro-finishing process

	Former	Current
Catalyst description	Ni,W on alumina with promoter	Pd on high surface carrier
Temperature, ℃	245~340	230~300
Pressure, kg/cm²G	155~190	155~190
Space velocity, kg/l/hr	1.0	1.0

developed. Catalysts and basic reaction parameters for hydro-finishing stage are summarized in Table 1.

Figure 1 shows a simplified process flow scheme of the UCO lube process that features simultaneously production of high quality base oils and medicinal grade white oils from fuels hydrocracker residue.

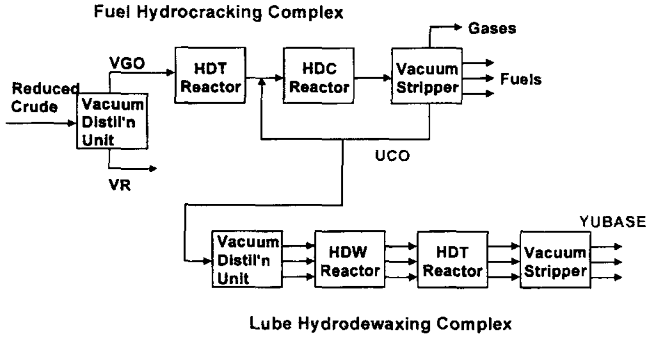

Fig. 1. SK's UCO lube plant process scheme.

Product Quality of UCO Lube Process

General performance of UCO lube process products

The UCO lube process produces 3 viscosity grades in 2 quality levels (API Group II, III quality) with viscosity index in the range of 110~135 and their refinement level is to be met FDA Regulation No. 178.3620(a) which is direct-contact food processing and packaging grade of white mineral oils. Table 2 shows some properties of those base oils as white mineral oils. As a severe hydrocracking base oils, the UCO process products named YUBASE have following advantages; high viscosity index, low volatility, excellent stability and very low toxicity.

As our preliminary study shows in Table 3, the UCO process product has superior quality in main performance areas such as viscometrics, low temperature properties, volatility and oxidation performance. Base oil properties are depend on composition ratio of saturates, aromatics and hetero-atoms. The main components of the UCO process product are paraffins and mono-naphthenes, which give good viscosity-temperature behavior and excellent oxidation stability. Oxidation stability or anti-oxidant response is important in the performance of most lubricants. Screening test results by RBOT and PCT demonstrate that the UCO process product has much better oxidation stability than conventional mineral base oils. The UCO process products contain much higher saturates and lower sulfur which are beneficial for oxidation stability and give good response to antioxidants, respectively. The narrow hydrocarbon distribution of the UCO process products gives very low volatility, which is similar to PAOs.

According to preliminary study of UCO lube process products in general performance areas, the UCO lube process products as high quality VHVI base oils are expected to be satisfactory for all straightforward applications. The VHVI base oil based lubricants offer advantages over conventional mineral base oil based lubricants in respect of many properties as Table 4.

We have tried to expand their application to specialty lubricants areas where advantages like low wax content, low volatility, narrow boiling range, good stability and high saturates of high qualty Group II, III base oils could be fully utilized. However, we had got some compatibility problem, which was related to lack of dissolving power of severe hydrocracked base oils.

Table 2. Typical properties of UCO lube process products

	YUBASE-3 (API Group II)	YUBASE-4 (API Group III)	YUBASE-6 (API Group III)
Physical characteristics			
Viscosity @40℃, cSt	12.3	19.1	32.5
Viscosity @100℃, cSt	3.1	4.2	6.0
Viscosity index	115	126	133
Flash point, ℃	196	220	234
Pour point, ℃	-24	-15	-15
CCS viscosity @-25℃, cP	<500	770	2220
Noack volatility, wt%	40	14.5	7.0
Chemical characteristics			
Total acid no., mgKOH/g	<0.01	<0.01	<0.01
Sulfur, ppm	<1	<1	<1
Carbon type distribution, % Cp/Cn/Ca	77/23/0	78/22/0	79/21/0
Refinement			
FDA 21 CFR 178.3620(a)	pass	pass	pass

Table 3. Comparison of 150 N grades in bench performances

	Solvent refined	Lube hydro cracking	VHVI YUBASE 6	Synthetic PAO 6
Low temperature property				
CCS viscosity @-20°C, cP	2100	2000	1230	900
@-25°C, cP	4500	4000	2220	1450
MRV vis. @-30°C, cP (1)	8840	7270	4430	2180
@-35°C, cP	21720	15540	8500	3510
Volatility				
Noack volatility, wt%	17.0	16.5	7.0	6.8
%Off @371°C by Sim-Dis.	10.4	8.3	<2	<1
Oxidation performance				
RBOT, min (2)	185	250	520	533
PCT, mg (3)	158	140	50	32

Note (1): Apparent viscosity by mini rotary viscometer of oils formulated with 0.5wt% PMA type PPD.
(2): ASTM D 2272 oxidation life of oils formulated with 0.3wt% Phenolic Antioxidant (Di-tert-buthyl phenol).
(3): Panel coking tendency of oils formulated with 13.0wt% ACEA A3/B3 performance additive and 10wt% OCP type VII.
PCT ran for 3hrs at 100°C of oil temp., 300°C of panel temp. and 20/20sec. of stop/go time.

Table 4. VHVI based lubricant advantages

Property / Improvement	Reason
Better low temperature properties	Low wax content, High VI
Low oil consumption and higher flash/fire points	Low volatility, Narrow boiling ranges
Better thermal and oxidative stability	High saturates, Good additive response
Good friction behavior and wear reduction	High VI, High paraffins, Good additive response
Environmentally Friendly	Low volatility, Low aromatics

Table 5. Comparison of 150 N grades in dissolving ability

	Solvent refined	Lube hydro-cracking	VHVI YUBASE 6	Naphthene
Aniline point, °C	100	116	126	79
Viscosity-gravity constant	0.82	0.80	0.78	0.87
Carbon type distribution, % Cp/Cn/Ca	57/38/5	64/35/1	79/21/0	47/42/11

Dissolving ability of UCO lube process products

There are many different ways of measuring the dissolving ability. Among them, well-accepted methods are aniline point, carbon type distribution and viscosity-gravity constant. The aniline point value tends to increase with both increasing viscosity and increasing degree of refining. The higher value of aniline point means the lower solubility. In general, dissolving ability is high in the order of aromatic, naphthenic, paraffinic oils. Viscosity gravity constant correlates well with aromatic content. A high viscosity-gravity constant leads to improved solubility. Carbon type distribution analysis is used to compare the dissolving ability of different oils by determining the proportion of carbon atoms in the paraffinic, naphthenic and aromatic structures.

The base oils produced by the UCO lube process have many desirable properties as lube base oils over those produced by conventional solvent refining or lube hydrocracking processes. However, more paraffinic nature of these highly refined stocks restricts their applications to specialty lubricant areas. For these product, the main problem of severe hydrocracking stocks like the UCO process product is lack of dissolving ability which is related to the difference in their composition, inherent high paraffin contents. This can be seen in parameters of dissolving ability of base oils, as given in Table 5.

According to our study, it was found that excellent specialty lubricants could be made by carefully selecting and formulating adequate additives and/or aromatic compounds. Moreover, these specialties with high quality VHVI base oils offer various advantages over conventional base oil based products.

Agricultural Spray Oils

Petroleum spray oils are used extensively in agriculture as insecticidal and miticidal agents. However, the use of spray oils is restrained by concerns that they may cause oil induced phytotoxicity to plant. Spray oils have to conform to standard criteria of physical and chemical properties in order to be used for tree fruit without fear of phytotoxicity. For reducing phytotoxicity potential, spray oils have to have narrow boiling range and high-unsulfonated residue level. Boiling range distribution is reported as temperature difference or carbon number difference between 90% distillation and 10% distillation measured by simulated distillation method. Spray

Table 6. Properties of agricultural spray oil from UCO process product

	YUBASE 4	General criteria
Viscosity @40°C, cSt	19.1	
Sulfur, ppm	<1	
Unsulfonated residue, vol%	>99	>92
Carbon type composition %Cp/ %Cn/ %Ca	78/ 22/ 0	
Boiling range by GCD		
10% off, °C	395.0	
90% off, °C	451.5	
90% off - 10% off, °C	56.5	<65
Carbon No. by GCD data 10%~90% off point	24~30	16~30

oils have generally carbon number distribution of C16~C30 to ensure low phytotoxicity and high pesticidal efficacy. Historically, another important property of spray oils is the level of unsulfonated hydrocarbons, which are determined by the amount of unsulfonated residue after incorporating a reaction with concentrated sulfuric acid. Unsulfonated residue values have generally 92% minimum, which minimizes phytotoxic aromatic components in spray oils.

The advantages of severely hydrocracked base oils like the UCO process products are their narrow hydrocarbon distribution feature and high unsulfonated residue level. Table 6 provides physical and chemical properties of agricultural spray oils from UCO process product.

Spray oils are generally sprayed at the state of oil/water emulsions, of which mixing ratio ranges from one to three percents oil in water. Therefore they are formulated with a minimum level of compatible surfactants. The emulsion should be quick-break type in order both to produce high volume of oil film on the leaf surface and to make the bulk water phase run off the foliage. After the emulsion breaks, the oil phase should spread laterally while dissolved onto epicuticular layer. On the contrary, stable emulsion type produces less oil film than quick break type.

Highly refined petroleum products like UCO process

Table 7. Surfactants for UCO process product in spray oil application

	Spray oil	General dosage
YUBASE-4, wt%	99.35	balance
Emulsifier package, wt% Nonylphenoxypolyetoxy ethanol 1-Decanol 1-Octanol	0.65	1~3

products have excellent compatibility with cuticular waxes layer of plant leaves owing to their inherent high paraffin content. However, as they have some compatibility problems with surfactants, they should be carefully selected and formulated. One example is illustrated in Table 7.

The non-ionic emulsifier package, which consist of nonylphenoxypolyetoxy ethanol, 1-decanol and 1-octanol, provides good stability and optimum emulsion properties at a lower dosage when they are blended with YUBASE. Another emulsifier package including polyoxyrthylene alkyl ether, span esters of fatty acid and nonylphenol etoxylate became hazy in appearance when they are blended into YUBASE.

The field test at Cheju Island was conducted by applying the above spray oil to citrus trees for control of mites. The emulsion ration of oil in water was 1%. The results for the control of pests such as mites, which have heavy resistance for insect strains, were equivalent to those obtained with chemical pesticide. Table 8 presents the field evaluations of UCO process product based spray oil.

The spray oil with UCO process product and Tebufenpyrad as a chemical pesticide were each applied to nine citrus fruit trees in Cheju Island when leaves were infested with 2~3 Panonychus citri (a mite). The spray oil with UCO process product was also applied to three citrus fruit trees to evaluate the leaf tip burn and fruits damage. The test result was confirmed non-phytotoxicity in 1% emulsion spraying, much more double concentration. Consequently, high quality VHVI base oils like UCO lube process products can be directly used in agricultural spray oils with optimal surfactants.

Table 8. Field test results of UCO process product based spray oil

	Spray oil	Chemical pesticide
Test field	Northern Cheju Island, Korea	
Applying plants	9 Trees of citrus fruit	
Target pests	Mites (Panonychus citri)	
Spraying pesticides	1% Emulsion spray oil	0.2% Tebufenpyrad
% Mortality		
@ 3 days after spraying	93.8	100
@ 7 days	98.7	100
@ 14 days	99.4	99.7
@ 21 days	99.4	99.5
Phytotoxicity in 2% emulsion spraying	None	-

Table 9. Test results of UCO process product as white oils

	PHAZOL-3	PHAZOL-4	PHAZOL-6	General criteria
Viscosity @ 40°C, cSt	12.3	19.1	32.5	
Sulfur, ppm	<1	<1	<1	<1
UV Abs. @260~350 nm, DMSO	0.018	0.020	0.021	<0.100
Readily carbonizable substance	Pass	pass	Pass	Pass

Table 10. Properties of 70 N grade white oils from UCO lube process and conventional process

	PHAZOL-3	70 N White oil from hydrocracking base oil	Remark
Yield test Acid Treating, vol%	-	89	by 3% Oleum + 5% EtOH
Composition analysis Paraffins, wt% Naphthenes Aromatics	 41.7 58.3 Trace	 30.6 69.4 Trace	ASTM D2549 and D2786
GC-Mass analysis Below C18, vol% Spike peak in GC graph.	 1.0 none	 3.4 detected	Spike peak →n-paraffins

White Oils

The terms white oil or white mineral oil are used to describe highly refined oils which are produced from lubricating base oils as feedstocks. In order to use as food grade white oils defined in FDA 21 CFR 172.878 and 21 CFR 178.3620(a) regulations, lubricating base oils have to be further refined in the conventional white mineral oil processes. The properties of white mineral oil produced in the conventional process are greatly influenced by the quality of feedstocks.

The base oils from UCO lube process under such conditions the noble metals based hydro-isomerization and hydro finishing process are inherently classified into food grade white mineral oils. In our tests, UCO lube process products satisfy the requirements specified in FDA 21 CFR 178. 3620(a). without further refining. Therefore, the UCO process products named PHAZOL as white mineral oils can be used in direct contact food processing and packaging areas. Table 9 presents the test results of UCO process product as white mineral oils.

According to recent toxicological research in laboratory animals exposed to white oils, it was demonstrated that normal paraffins are apparently more readily absorbed into the skin than branched isoparaffins and cyclic alkanes (Reference 4). Moreover, hydrocarbons below C18 are more readily absorbed than the ones above C18. White oils used for the manufacturing of foods, medicine and cosmetic industries require warranty regarding these hydrocarbon compositions. Therefore, it is necessary both to decrease the normal paraffin content and to increase the isoparaffin content of the white oils. The white oils from the UCO process products have high proportion of isoparaffins due to selective isomerization of the normal paraffins to isoparaffins through the hydroisomerization dewaxing process.

Inherently high isoparaffins content and narrow hydrocarbon distribution of the UCO process products provide many advantages for preparing high quality white oils. The gas chromatographic analysis demonstrated in Fig. 2 illustrates that the white oil from UCO process does not contain any strong

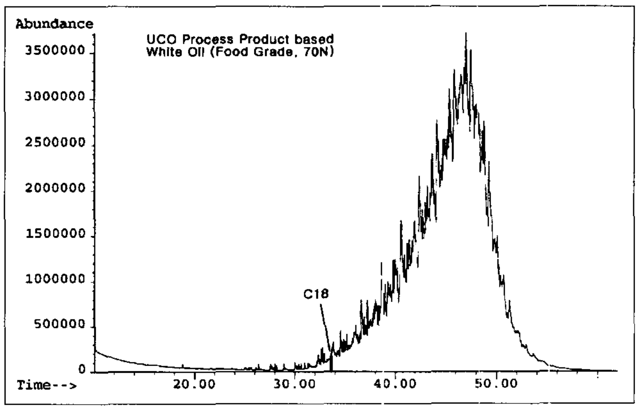

Fig. 2. GC-Mass analysis data of white oil from UCO process.

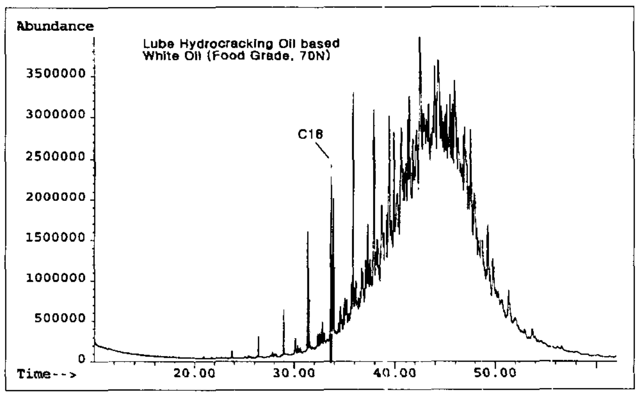

Fig. 3. GC-Mass analysis data of white oil from lube hydrocracking base oil.

spike peak that indicates existence of normal paraffins. The hydrocarbon content of below C18 is very low 1.0vol%, compared with 3.4vol% of conventional white oil from lube hydrocracking base oil. Table 10 compares properties of 70N-grade white oil from UCO lube process directly with conventional white oil by further refining from lube hydrocracked base oils.

Coning Oils

The term coning oils is used to describe the lubricants used for decreasing friction between fibers in the textile process. The coning oils require such properties as no discoloration of fiber, good washing property and less friction coefficient. Additionally, good anti-electrostatic property, low evaporation at high temperature, no effect on the dye treating process and corrosion preventive are needed for trouble free operation of textile machines. Among these requirements, discoloration, washing property and evaporation loss are strongly related the base oil used in final products.

For long time, conventional base oils have been used in this application because conventional base oils are relatively economical and emulsify easily with small amount of surfactants. However, these grade base oils have poor stability under UV and hot ambient. Then, the quality of final texturing fibers drops down by unacceptable quality of coning oil from time to time. To prevent this quality down, the storage period and delivery of coning oils with conventional base oils should be very short.

The YUBASE 3 based coning oil is superior stability to conventional base oil under UV and thermal condition, because the UCO process product contains less aromatic hydrocarbon and impurities that cause settle-down and precipitation. These settle-down and precipitation are believed to be initiators of fiber discoloration.

In order to get washing ability with fibers, coning oil should be emulsified with tap water in ambient temperature. However, the UCO process product is not easily emulsified with surfactants that are developed for conventional base oils. This disadvantage of paraffinic base oils like the UCO lube process products have been able to be overcome by balancing surface-active agents. To achieve good compatibility with surfactants in coning oil application of the UCO process product, we controlled surfactant types and their dosages as illustrated in Table 11.

Table 11. Surfactants for UCO process product in coning oil application

	Coning oil
YUBASE-3, wt%	92
Emulsifier package, wt% Polyoxyethylene oleyl ether Sorbitan monooleate Phosphate ester Etoxylated nonyl-phenol Oleic acid	8

While the reliable and repeatable test procedure for the evaluation of washing ability of coning oil has not been established yet in textile industry, emulsion stability is usually used as a procedure to distinguish the difference of emulsifying properties in field. Table 12 shows the emulsion stability of the UCO process product based coning oil and other conventional base oil based. Although the UCO process product is very paraffinic and has little aromatic and polar compounds, coning oil with the UCO process product makes quite stable emulsion as shown in Table 12.

Furthermore, the UCO process product has very low evaporation loss compared with conventional base oils as shown in Table 3 and Table 12. For this reason, the UCO process product based coning oil results in less fume and oil vapor in practical operation.

Transformer Oils

Transformer oils are used extensively in electric transformer for the purpose of insulating electric currency and cooling the core of transformer. Generally, transformer oils require the following properties; good dielectric properties, good conventional cooling effect, good oxidation and thermal stability, low temperature flow ability, less fire hazard and no reactivity with metals.

Meanwhile, mineral base oils of naphthenic type are used in most transformers in service. The use of paraffinic transformer oils is very limited and less than a quarter of total demand. Owing to their properties like lower pour point and gas

Table 12. Properties of conventional and UCO process product based coning oils

	Conventional		YUBASE-3 based
	Oil A	Oil B	
Appearance of emulsion	Yellowish	milky white	milky white
Emulsion stability (1)			
Light emulsion, %	90	-	-
Clear emulsion,%	8	100	100
Oil layer, %	2	-	-
Total acid No., mgKOH/g	0.34	1.78	0.50
Evaporation loss, wt%	13.70	13.02	4.02

Note 1) Stability of 10% solution in tap water, after 24 hrs

Table 13. Properties of naphthenic, paraffinic and UCO process product based transformer oils

	Naphthenic oil	Hydro-treated paraffinic oil	YUBASE-L3
Viscosity @40°C, cSt	11.73	8.38	12.12
Flash point, PMCC, °C	136	144	194
Pour point, °C	-33	-21	-42
Copper corrosion @100/3 hrs	2-a	1-b	1-a
Dissipation factor, %	<0.001	0.002	0.03
Impulse breakdown voltage, point/sphere @3.2 mm, kV	48	90	77.5
Gassing tendency @8KV/50°C, μl/min			
Oxidation stability @125/75 hrs TAN, mgKOH/g	0.20	0.38	0.19
Volume resistivity @80°C, Ωcm x10^{15}	-	-	1.63
Carbon type distribution, Cp/Cn/Ca, %	-	-	76/24/0

Table 14. Gassing tendency of conventional and YUBASE L3 based transformer oils

	Conventional Base Oil		Severe hydrocracking base oil	
	Paraffin	Paraffin + Naph.	YUBASE L3	YUBASE L3 + 1% C13 Arc. (1)
Gassing tendency, μL/min	+11	-2	+31	-23

Note (1) : C13 Aromatic compounds is aromatic hydrocarbon mixture of carbon no.10~13 with two benzene rings.

absorbing, as shown in Table 13, naphthenic base oils are used more often than paraffinic base oils for the electronic insulating oil application. However, regarding such dielectric properties as breakdown voltage, dissipation factor and volume resistance, untreated or moderate treated naphthenic oils are poor compared with paraffinic oils. Furthermore, not severely treated naphthenic oils tend to make corrosion or discoloration on the activated copper surface and have poor thermal and oxidation stability.

Sometimes, the naphthenic based transformer oils become brownish and makes varnish on the copper surface in transformer after operated 10 to 20 years. To prevent this adverse effect, large amount of clay and sulfuric acid treating are needed. Some local transformer oil manufacturers put unstable antioxidant into the oil without theoretical study and field performance record. In the case of paraffinic base oils, single paraffin-based transformer oil can not work at the low ambient temperature because of its poor pour point. When ambient temperature goes down to below its pour point, the oil nearby the wall of transformer will not circulate. Then removing heat from the core to outside by its natural convention mechanism is impossible and then the electric circuit becomes off.

Except for high pour point, paraffinic oil has another disadvantage as a transformer oil, that is, worse gassing tendency. In the transformer, arc and high voltage currency occur during voltage down operation. This high voltage attacks the surface of material like core copper metal, cellulose paper and etc. This attack makes some gases like hydrogen, CO, CO_2, etc. coming out from transformer. Sometimes, this phenomenon is applied for the inspection of defected parts by high voltage attack in transformer without looking inside. However, if the gases are not removed quickly, accumulated gases concentration could be the cause of explosion of transformer. Therefore, transformer oil has to have ability absorbing these high potential gases on the solid surface. In the transformer oils, these gases are very unstable making a free radical and an ion. The mechanism, how to absorbed these gases in the oil, has not been clarified yet. Most paraffinic oils have poor gas absorbing property and some of paraffinic oils even make gases by decomposition of its hydrocarbon chain.

One of the UCO process products produced by deep dewaxing, YUBASE-L3, has quite suitable properties for a transformer oil, as shown in Table 13, despite of containing high paraffins and low aromatics. The UCO process product has very high flash point compare with similar viscosity grade naphthenic and hydro-treated paraffinic base oils. That decreases the fire hazard of transformer. The UCO process product is very stable and makes less corrosion on the metal surface because its feed stock has no sulfur compounds. Regarding the dielectric properties, the UCO process product is typical paraffinic oil so that all properties are quite good and marginal.

It is well known that the gassing tendency restricts the application of paraffinic oils in high voltage transformer. In our laboratory study, PXE (para xylyl ethane), LAB (linear alkylbenzene), C13 aromatic hydrocarbon mixture and C17 aromatic hydrocarbon mixture are investigated regarding their influence on insulating oil's gassing tendency performances. The gassing tendency was found as a highly sensible property, changing with treating aromatic hydrocarbons. The higher benzene ring content in the hydrocarbon, the better gassing tendency. The UCO process product based transformer oil with treated small amount of aromatic hydrocarbon has better gassing tendency than conventional base oils based transformer oils as shown in Table 14. Gassing tendency performance of highly paraffinic base oils like UCO lube process product can be improved by adding some aromatic compounds.

Summary

The base oils produced by the UCO lube process have many desirable properties as high quality lube base oils over those produced by conventional solvent refining or lube hydrocracking processes in main performance areas such as viscometrics, low temperature properties, volatility and oxidation characteristics. However, various compatibility problems are expected due to the lack of dissolving power by high paraffinicity of those base oils, when specialty lubricants are formulated with severe hydrocracking base oils like the UCO lube process products.

According to our preliminary study and field test results, these problems in specialty lubricants area with severe hydrocracked base oils like the UCO lube process products could be overcome by carefully selecting and formulating adequate additives and/or aromatic compounds. Moreover, these specialties with the UCO process products offer various advantages over conventional base oil based products.

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