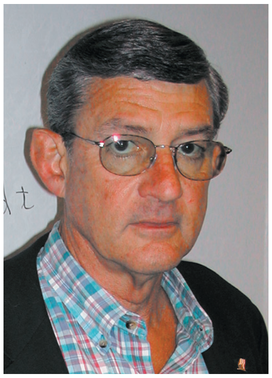
Lubricant base oils



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Contributing Editor

To chemically create quality lubricant from crude oil, manufacturers really have to use their noodles.

Often in this space we talk about the importance of viscosity in understanding lubricant theory and practice. Now let's turn to the base oils used to formulate lubricants. And, no, you won't need a doctorate in chemistry to follow along.

First, base oils are the primary ingredient in oils and greases. Most oils are formulated with 70% to 99% base oil and the rest being additives. Greases typically have 70% to 94% base oil. These base oils come from three primary sources:

1. Crude oil
2. Chemical synthesis
3. Natural Resources other than crude oil (fats, waxes, vegetables, etc.)

For this article, we will discuss only the first, i.e., crude oil, and how it is converted to the mineral oils that can be used as the base oil in lubricant products.

Crude oil, like coal, is formed naturally through nature's processes of heat, decomposition and extreme pressure. When crude oil is taken from the ground, it is composed

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Figure 1.

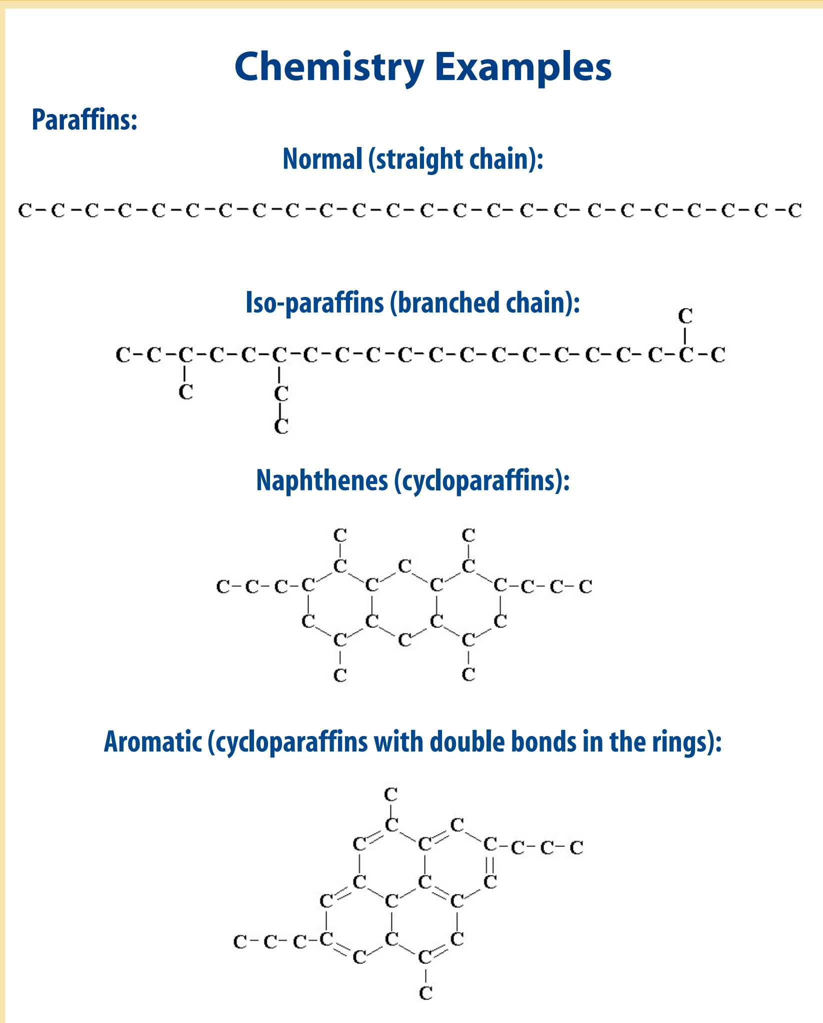
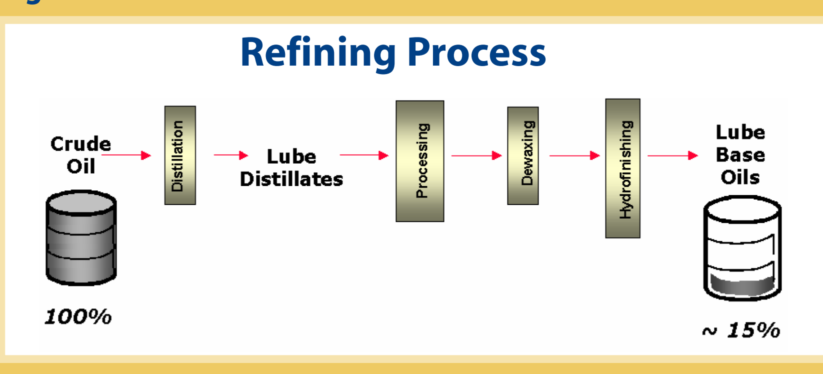


Figure 2.



of many different kinds of chemical materials all mostly based on carbon (C).

I like to think of crude oil as being analogous to a mixture of every kind of cooked pasta you have ever seen: spaghetti, lasagna, ziti, shells, rotini, noodles, linguini, stars, etc. It is all flour but in many different forms. We have learned that the long straight pasta, like spaghetti, generally makes the best pasta (or, to follow the analogy, lubricant).

In the refining process, we separate the different kinds of pasta into the different types through processes of distillation (kind of like removing the very big and the very little pieces), cracking (like breaking the very long pieces of pasta like linguini and spaghetti into shorter pieces), hydrogenation (converting some pieces into others), dewaxing (removing certain large types like lasagna) and so forth. But we don't want to get too carried away with this analogy.

Our crude base oil mostly has carbon compounds of 25 to 45 carbon atoms and can be classified into four primary types: paraffins, naphthenes (or cycloparaffins), aromatics and heteroatom compounds (containing atoms in addition to carbon (C), like Sulfur (S), Oxygen (O), Nitrogen (N) and the like).

For those of you interested in the chemistry, see the following examples in Figure 1.

Heteroatom compounds contain atoms in addition to carbon (C), like Sulfur (S), Oxygen (O), Nitrogen (N) and the like. These atoms can occur in certain locations in the adjacent diagrams. These compounds are not of interest and need to be removed because they tend to cause the base oil to be unstable, adding color or deposits, or contribute to low viscosity index (VI). Remember VI refers to the stability of viscosity vs. temperature; high VIs are less sensitive, thinning less at higher temperatures.

Enough chemistry for now, the refining process is schematically shown in Figure 2.

While the refining process is basically similar, different companies and the different grades of base oils undergo varying degrees of the basic process. Generally, in the first step, cracking and distillation, we break up the really large pieces and sepa-

Figure 3.

Properties Mineral Oils

	Solvent Extracted	Hydrotreated	Wax Isomerized
API Group	**I**	**II**	**III**
Viscosity, mm2/s @ 100°C	3.9	4.0	3.9
Viscosity, mm2/s @ 40°C	18.7	19.6	16.2
Viscosity Index	100	101	142
Volatility, wt. % (Noack)	27	28	16
Pour Point, °C	-15	-15	-21
Aromatics, wt. %	17	0.6	0.3
Saturates, wt. %	83	99.4	99.7
– Paraffins	32.8	23.5	86.1
– Cycloparaffins	50.2	75.9	13.6
Sulfur, wt. %	0.3	0	0

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rate the light (volatile) and heavy (not very volatile) to form that group of carbon compounds between 25 and 45 carbon atoms, which we can call lube distillates.

The second step, processing, can include solvent extraction, dewaxing and hydrotreating. The degree to which these are done defines the ultimate grade or quality of the final base oil.

In these steps, solvent extraction, a conventional refining process, involves preferential removal of aromatics.

Dewaxing involves removal of a very long chain, high-melting paraffins. A low temperature solvent process conventionally does dewaxing where the wax is crystallized out of the oil. Catalytic dewaxing uses a catalytic chemical process to convert waxy material into iso-paraffins. This results in higher yields, lower pour points (flows better at low temperature), and higher VIs—all good properties.

Hydrotreating basically involves treating the base oil with hydrogen, which removes carbon-to-carbon double bonds that can occur in aromatics and in unrefined (not pure) paraffinics. These double bonds are shown in the aromatic example in Figure 1 as two parallel lines, C═C. Note: When people talk about polyunsaturated fats being better for you, what they mean is fat with more double bonds are easier to digest because there is something for your body to react with. Likewise with hydrotreated paraffins, there is less for nature (heat, chemicals, etc.) to react with. As a result they are more stable—and better for lubricants.

The degrees to which these steps are carried out on the crude oil distillate define the ultimate properties of the base oil. These properties are grouped into so-called group I, II, & III base oils, where group III are the most highly processed, most expensive and highest performing of the crude oil-derived mineral oils. Figure 3 shows a chart of the different properties of these three groups.

Base oils are an integral part of any lubricant formulation. Generally the performance of a lubricant is primarily influenced by the quality and, as we have seen earlier, the viscosity of the base oil. <<

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