What Does PTFE Mean To Lubrication?

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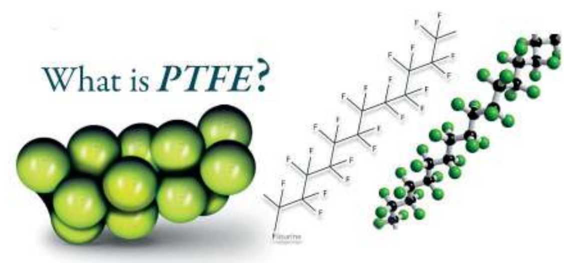
Industrial society moves on films of oil. In recent decades, the chemical characteristics of those films have evolved from rather simple to extremely complex.

Modern machines also have advances in technology that make them increasingly dependent on complex lubrication. The technical requirement for increased performance and decreased size in internal combustion engines has several drawbacks such as smaller bearings and higher operating temperatures.

Traditionally, as loads, speeds, and temperatures increased, the lubrication chemist relied on oil's viscosity at operating temperatures to perform its well-known functions. Lubricating films separate machine parts and keeps wear at acceptable levels.

The push for increased energy savings required low viscosity lubricants, however. While this relieved the machine of the energy-wasting chore of shearing its own oil films, it is not entirely consistent with the parallel goals of long life and low wear, easy start-up, and minimum stick-slip. As a result, complex additives are used to achieve these goals.

One way to get around the contradictory requirements of low viscosity at low temperatures and sufficient viscosity at high temperatures is to incorporate lubricating colloids in the oil. Graphite and molybdenum disulfide were used in the past but they turned the oils black. Lead naphthenate and borates have also been tried. Toxicity and water solubility limited their use. Zinc dithiophosphate, discovered in the 1940s, was later phased out as it poisoned catalytic converters. At one time, zinc dithiophosphate was thought to be one of the best anti-wear additives ever discovered. Another proven approach engineered and patented in the 1980s is to incorporate colloids of PTFE into lubricants. With proper chemistry, desirable results with no discoloring of the oil, no plugging of oil filters and no slug accumulation have been accomplished.



Chemical makeup of Polytetrafluoroethylene

Applications of PTFE in Crankcase Oils

The internal combustion engine's crankcase is a chemical sewer. It is alternately hot, cold, bathed in combustion gases, soot, metallic wear debris and abrasive grit from the air the engine inhales. It is diluted with fuel and condensed water and an occasional (often catastrophic) dose of ethylene glycol from head gasket leaks.

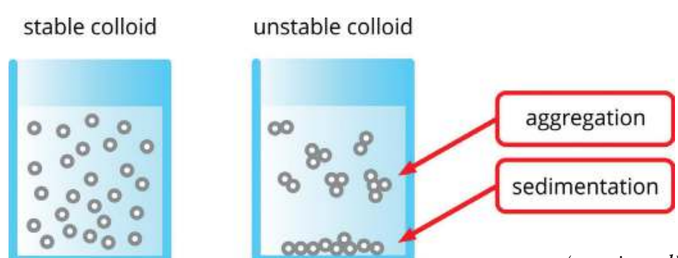
The engine is not lubricated by oil alone. What it is lubricated with is far from simple. Complex populations of particles start collecting after an oil change and increase with time. By definition and with microscopic examination showing Brownian movement, these are shown to be colloids. Since working oils are loaded with colloids as the result of normal use, it makes sense to use colloids towards creating a better lubrication.

PTFE has many desirable characteristics and has been instrumental in using colloids in lubrication. PTFE stands for Polytetrafluoroethylene, which is a synthetic fluoropolymer. Water and water-containing substances do not wet PTFE; therefore adhesion to PTFE surfaces is inhibited. It is very non-reactive, and so is often used in containers and pipework for reactive and corrosive chemicals. When used as a lubricant, PTFE can reduce friction, wear, and energy consumption of machinery.

PTFE colloids, well known for their low friction, have at first glance, great appeal as oil additives. However, the fact that PTFE colloids don't like water or oil has made their use in that application far from simple. PTFE cannot just be stirred into an oil to make a satisfactory lubricant. The dispersion chemistry and additives used must be chosen with great care and the dispersion technique is extremely important. Powerful synergistic interactions exist with some additives. When properly done, extraordinary lubricants result and a new class of lubricants with remarkable low friction and wear has been accomplished. Four-ball tests show low wear and a coefficient of friction of .029 for a fully formulated lubricant based on this technology.

Variations in Stability

When proper dispersion methods are not used with PTFE, separation of oil and particles, clumping, and settling occur. In some cases the particles form spheroids that can't get between tight-fitting working surfaces, plus are rapidly removed from the oil by conventional automotive filters.



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When PTFE is properly dispersed in engine oil, there is no tendency for particles to form clumps, and sedimentation is very slow (years) and, even then, redispersion is easy. Superior lubricants with remarkable properties can be formulated using the techniques that produce this type of dispersion.

Laboratory work using the 4-ball test has shown that these lubricants, used both as concentrates and as additives to other lubricants, have extraordinarily low friction and wear. Engine tests in the U.S., Australia, Israel, the Netherlands, and Canada have confirmed that laboratory results correlate closely with the performance of machines in actual practice.

Benefits of PTFE Technology

Using the right colloidal chemistry to disperse PTFE provides added benefits beyond low friction and wear. Lubricants utilizing PTFE colloids may also:

- Provide increased horsepower
- Improve efficiency
- Decrease wear and tear on engines and moving parts
- Extend time between rebuilds
- Provide protection through rust inhibitors
- Improve boundary films

Another added, but unexpected, benefit is a cleaner internal engine. Properly formulated, colloidal chemistries keep unwanted particles and sludge in suspension, allowing filters to sift them out.

Conclusion

Engineers are constantly trying to get more and more power out of less and less machinery. One solution is to use low viscosity fluids containing carefully dispersed lubricating colloids to take the place of high viscosity oils in preventing metal to metal contact and the related high friction and wear. Machines of the future will require lower viscosity lubricants; power density increases as the machines are made smaller. Lubricants with colloidal PTFE are a perfect solution to the problem of the need for oils with low viscosity at low temperatures and sufficient viscosity at high temperatures.■

Franklin G. Reick is in the New Jersey Inventors Hall of Fame and has dozens of U.S. and international patents to his name. He founded Fluoramics, Inc. in 1967, is a recognized speaker in the lubricant arena, and has published many technical articles on the subject. Franklin resides in New Jersey and continues his work on innovative lubrication and rust-stopping products. For more information, visit www.fluoramics.com.

This article is edited and updated from "Variability of PTFE Colloids in Nonaqueous Systems and Lubricating Oil," originally published in 1988 in STLE Lubrication Engineering, Vol. 44, No. 8, pp. 660-664, Journal of the Society of Tribologists & Lubrication Engineers. Franklin G. Reick procured several patents in PTFE colloidal chemistry and is the chemist behind the founding of Tufoil Technologies and Fluoramics, Inc.

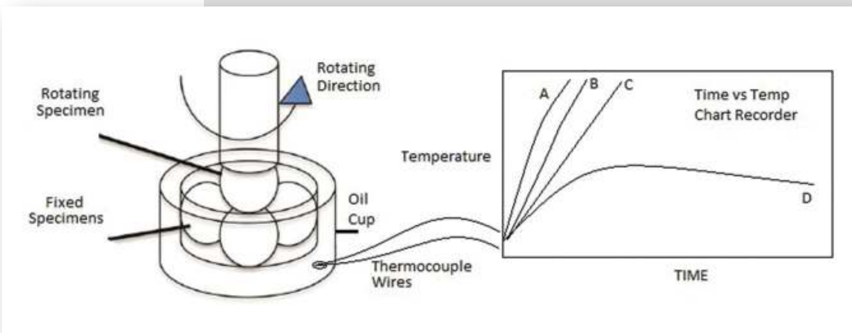
Why 4-Ball Tests?

There are many methods for testing lubrication oils… each is used for a different purpose. Some tests are good for gear oils, some are good for testing cutting oils, and other are best for testing engine oils. S. M. Hsu and R. S. Gates of the National Bureau of Standards published several papers showing that the 4-Ball Test correlates with engine oil performance. Pin-on-Disk is another correlation test.

The 4-ball wear-test method is used to determine the relative wear-preventing properties of lubricants in sliding steel-on-steel applications. Three ½" (12.7-mm) diameter steel balls are clamped together and covered with the lubricant to be evaluated. A fourth ½" diameter steel ball, referred to as the top ball, is pressed with a force of 40 kgf (392 N) into the cavity formed by the three clamped balls for a three-point contact. The temperature of the lubricating grease specimen is regulated at 75°C (167°F) and the top ball is rotated at 1200 rpm for 60 min. Lubricants are compared by using the average size of the scar diameters worn on the three lower clamped balls.

The top ball is rapidly rotated on top of the three lower balls in order to measure scar diameters.

Ball scar measurements and the subtle self-generated frictional heat created by this test are the two best measures of lubrication qualities. One downfall to the ASTM 4-Ball Test is the inability to capture and data log the time versus temperature changes.



Schematic of 4-Ball Test device