The Los Angeles Silhouette Club

Bullet lube ingredients/descriptions & Lube Recipes

By: Rick Kelter

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There are far too many "*possible*" ingredients that could be used in bullet lube to list but many of the more common ones (and a few rather odd ones) are described below.

For a more detailed description of what you need your bullet lube to accomplish and how it does (or doesn't) work see chapter 5, From Ingot to Target: A Cast Bullet Guide for Handgunners

For an excellent discussion on lube making refer to this thread on the Castboolits forum.
(Click image for link)

Thinking of making your own lube? Here are descriptions of many common ingredients including their uses and sources. With the following ingredients you can make virtually an unlimited number and variety of bullet lube recipes, but before you get started here is an excellent article on what it is you need your lube to accomplish . . .

Lubricating Cast Bullets By: Glen E. Fryxell

OK, I'm going to ask a stupid question. What does bullet lube *do*?

I'll bet most of you answered that bullet lube lubricates the passage of the bullet down a rifled bore, to eliminate galling of a soft metal as it traverses a hard metal cutting edge. Well, yeah, I suppose that's true enough, but that's not all it does, nor is it necessarily even the most important job that it does. Let's assume for the moment that lubrication is the sum total of its job -- is the lube on a given bullet lubricating the passage of the bullet that carries it, or the bullet that follows after it? Another way that I've had this question posed to me was, should the lube groove (s) be on the front of the bullet (where they could lube the passage of that bullet), or towards the rear of the bullet (where they could leave a healthy lube film for the next bullet in line)?

Part of the problem with this line of reasoning is that it assumes that the lube is delivered to the bore by simple bullet/barrel contact and smearing, and hence the lube can only lube that which is behind the reservoir (lube groove). Looking at things in this manner results in a fairly simplistic, almost static picture (hard surface, soft surface, slippery stuff in between), and the firing of a revolver shot is a very dynamic process. What *else* does bullet lube do? Or perhaps more accurately, what else is done *to* the bullet lube?

Let's just set the record straight, lube is not simply smeared from the lube grooves onto the bore, nor is lubrication the sole function of bullet lube.

There were a couple of excellent articles published a few years back in The Cast Bullet on lube pumping mechanisms. In a nutshell, the conclusions were that bullet lube was pumped to the bore surface by 3 different mechanisms -- compression, linear acceleration and radial acceleration. In compression, the force applied to the base of the bullet causes the compression of the bullet's core underneath the lube groove, resulting in expansion of the core diameter and shrinkage of the lube groove width. Both of these factors results in the reduction of the volume of the lube groove itself, and hence compress the lube and force it to the bullet/barrel interface. There is solid physical evidence supporting this mechanism (especially in rifles). The linear acceleration mechanism is pretty straightforward -- the inertia of the lube at rest causes it to be forced towards the rear of the lube groove as the bullet is accelerated forward by the burning powder. When the lube encounters the beveled (or radiused) rear face of the lube groove, it is once again forced to the barrel surface. In the third lube pumping mechanism, radial acceleration, as the bullet begins to spin faster and faster as it progresses down the barrel, at some point sufficient radial acceleration (think "centrifugal force") is generated to overcome the viscosity of the lube and it gets flung off of the lube groove surface and outward onto the barrel. All three of these mechanisms come into play when any cast bullet is fired, although the magnitude of each will vary significantly with the application (e.g. .38 target wadcutter vs. .30-06 or .45-70 hunting load), and will be dependant on velocity, pressure, alloy hardness, bullet diameter, etc. Indeed, the magnitude of each will vary for any given shot, depending on where the bullet is in the barrel -- linear acceleration will be dominant early in the shot, compression will take over as pressure peaks and radial acceleration will become more significant as the velocity increases.

Delineation of these mechanisms provides a significant level of understanding in terms of cast bullet shooting and design, as well as bullet lube formulation. However, these mechanisms still have the bullet serving as nothing more than a brute-force paintbrush, slapping on a fresh coat of grease of the bore for the next bullet in line. This is all well and good, but it is an incomplete description of the process. I believe that there is another mechanism operating, one that accentuates a second and perhaps even more important role that bullet lube serves.

Back in the 50s and 60s, some very knowledgeable Handloader's performed extensive tests to understand what made the best bullet lube and why. One of the more notable efforts in this area was the work done by E. H. Harrison of the NRA Technical Staff. These results were originally published in the American Rifleman, and were subsequently reprinted in "Cast Bullets" by E. H. Harrison, and available through the NRA (buy this book if you don't already have it!). The most important property of the lube formulation was found not to be the inherent lubricity of the mix, but rather its flow properties (we will return to this shortly). It is interesting to note that Mr. Harrison was singing the praises of moly loaded bullet lubes back in the 1950s. It seems "the wheel" has been rediscovered…

Why are flow properties important? Most barrel tolerances are generally good to less than .001", where can the lube flow *to*? As the bullet undergoes the violence of being engraved by force, if there is *any* slippage or variation in groove/land width, this will result in there being a gap between the trailing edge of the land and the groove engraved in the bullet’s face. Gas molecules are very, very small things, and at the temperatures and pressures of burning powder they‘re buzzing like an angry swarm of hornets.

Even a gap between the trailing edge of the land and the engraved groove of the bullet of only .001" will leave enough room for over 50,000 of these gas molecules to line up "shoulder to shoulder" and still not bump into the outer boundaries of the gap.

The point of bringing all this up is to show how easy gas leakage is through this sort of defect channel, even though at first glance it appears to be quite small. In addition, there are similar (somewhat smaller) channels on the grooves and lands, left over from the machining processes that gave rise to the rifling, and these defects also contribute to potential gas leakage. Gas pressure rises much faster than the bullet is accelerated, so therefore as the bullet’s surface is ravaged by the lands and gas leaks past the base band, the lube reservoir becomes pressurized, with the gases entering from the rear and pushing forward. This rapid pressurization forces the lube to flow into the defect channels in the engraved driving band in front of the lube groove, sealing off the gas flow and limiting the damage due to gas cutting. If the cast bullet is appropriately sized, then this controlled injection forms a floating pool of lubricant that follows the bullet down the barrel, lubricating the bullet/barrel interface and sealing the high-pressure gases. Kind of a ballistic stop-leak, if you will.

This is why some of the new hard lubes perform their best at higher pressures. Gas leakage into the lube groove melts the lube, and the liquid lube then gets forced into the microscopic defect channels ahead of the groove. Some of the commercial hard lubes work just fine at 800 fps and 1300 fps, but at intermediate velocities or say 1000 fps, they lose some of their shine. At the lower velocities/pressures there are few demands placed on the lube, and these can be addressed by simple frictional smearing of the lube displaced from the lube groove by the land. As the pressures/velocities rise into the intermediate range (+P level, 20,000 psi, 1000 fps) however, the mechanisms outlined above can’t pump the hard lube to the bullet/barrel interface fast enough to keep up with the lubrication/sealing demands of the system, resulting in leading and poor accuracy. As pressures/velocities climb into the magnum level (35,000 psi, 1300+ fps), enough hot gases are injected into the lube groove to melt some or all of the hard lube, allowing all of the lube pumping mechanisms outlined above to come into play, resulting in effective lubrication. These high-pressure gases also cause the molten hard lube to be injected into the defect channels in the forward driving bands, thereby sealing off gas cutting. Lube pumping and high-pressure injection cannot take place efficiently until a hard lube melts. For a soft lube, it’s not necessary to melt the lube for this injection to happen, the soft lubes are capable of flowing from the start, which is why they lubricate cast bullet revolver loads effectively across the entire range of velocities from 600-1500 fps. The commercial hard lubes are well-suited for magnum revolver and rifle cast bullet velocities.

Undersized cast bullets leave a gap between the bullet and barrel, leaving them unable to restrict this pressure-induced lube flow. As a result, the lube very quickly gets blown out of the barrel in front of bullet, leaving the bullet "naked", un-lubricated and unprotected. This phenomenon is especially problematic with the hard lubes; once molten, the low viscosity liquid lube gets blown out rapidly if the bullet is undersized.

Concerning the flow properties vs. lubricity issues cited above, E. H. Harrison explored the use of molybdenum disulfide (aka "Moly") as a bullet lube back in the 1950s. He found that dry moly was inadequate as a bullet lubricant for .30-06 loads at 2000 fps, but that when it was incorporated into a more traditional grease/wax lube formulation, that it worked quite nicely indeed. By incorporating moly into a soft lube, the desirable flow properties of the lube are maintained, as is the ability to leave behind a moly coating on the barrel. This Moly coating serves to protect the bore from oxidation, in addition to serving as a lubricant, preventing adhesion of leading deposits. More recently, a lot of work has been done looking at hard-cast bullets dry coated with moly, and this has been found to work nicely for routine handgun velocities in the 800-1000 fps range. These observations reinforce the conclusion that simple lubrication is sufficient at lower velocities, but as pressures and velocities climb, the role of bullet lube is also that of a fluid gasket to seal the bullet/barrel interface.

In summary, bullet lube is pumped from the lube groove to the barrel surface by compression, linear acceleration and radial acceleration. In addition, lube is injected forward during the firing process, as the result of high-pressure gas leakage into the lube groove. This injection process forms a floating fluid gasket around the bullet, and serves to limit gas cutting and is a kind of ballistic stop-leak. Hard lubes must first melt before they can be pumped or injected by any of these mechanisms. By incorporating Moly into the mix, the lube delivered to the barrel surface can serve to prevent adhesion of future leading deposits by passivating the steel surface. Glen E. Fryxell

Beeswax

Beeswax is secreted by honeybees of a certain age in the form of thin scales. The scales are produced by glands of 12 to 17 days old worker bees on the ventral (stomach) surface of the abdomen. Worker bees have eight wax-producing glands on the inner sides of the sternites (the ventral shield or plate of each segment of the body). Wax is produced from abdominal segments 4 to 7. The size of these wax glands depends on the age of the worker.

Honeybees use the beeswax to build honey comb cells in which the young are raised and honey and pollen are stored. For the wax-making bees to secrete wax the ambient temperature in the hive has to be 33 to 36 °C (91 to 97 °F). Approximately eight pounds of honey is consumed by bees to produce one pound of beeswax (8 kg/kg). Estimates are that bees fly 150,000 miles to yield this one pound of beeswax (530,000 km/kg). When beekeepers go to extract the honey, they cut off the wax caps from each honeycomb cell. Its color varies from yellowish-white to brownish depending on purity and the type of flowers gathered by the bees. Wax from the brood comb of the honeybee hive tends to be darker than wax from the honey comb. Impurities accumulate more quickly in the brood comb. Due to the impurities, the wax has to be rendered before further use. The leftovers are called slumgum.

The wax may be clarified by heating in water and may then be used as a lubricant for bullets, drawers and windows, as a wood polish or in candles etc. As with petroleum waxes it may be softened by dilution with vegetable oil to make it more workable at room temperature.

Rendering Beeswax: *Cut the wax into chunks. Wrap in two layers of cheesecloth and tie the cheesecloth securely. Fill a large stainless-steel or tin-plated pot with water. (Other metals can discolor the wax.) Put the wax in cheesecloth into the pot and weigh it down with a brick or other heavy object. Bring the water to a temperature of about 190 degrees F. Do not let it boil, as this will damage the wax, causing it to be brittle. Simmer the wax until it is all melted. As it melts, the wax will flow out of the cheesecloth, leaving most of the debris behind. The wax will float on the top of the water.*

Remove the wax from the water and let cool. If the wax still has a lot of debris in it, repeat this process using four layers of cheesecloth. Some debris, called slumgum, will remain on the bottom of the wax. Slice this off with a hot knife.

Physical characteristics: It is a tough wax formed from a mixture of several compounds including: hydrocarbons 14%, monoesters 35%, diesters 14%, triesters 3%, hydroxy monoesters 4%, hydroxy polyesters 8%, acid esters 1%, acid polyesters 2%, free acids 12%, free alcohols 1%, unidentified 6%.

The main components of beeswax are palmitate, palmitoleate, hydroxypalmitate and oleate esters of long-chain (30-32 carbons) aliphatic alcohols, with the ratio of triacontanylpalmitate $CH_3(CH_2)_{29}O\text{-}CO\text{-}(CH_2)_{14}CH_3$ to cerotic acid $CH_3(CH_2)_{24}COOH$, the two principal components, being 6:1.

Beeswax has a high melting point range, of 62°C to 64°C (144°F to 147°F). It does not boil in air, but continues to heat until it bursts into flame at around 120°C (250°F). If beeswax is heated above 85 °C (185 °F) discoloration occurs. Density at 15°C is 0.958 to 0.970 g/cm^3.

Bees wax can be classified generally into European and Oriental types. The ratio of saponification (to convert (a fat) into soap by treating with an alkali) value is lower (3-5) for European beeswax, and higher (8-9) for Oriental types.

Hydroxyoctacosanyl hydroxystearate can be used as a beeswax substitute as a consistency regulator and emulsion stabilizer. Japan wax is another substitute.

Grease (lubricant)

Grease is a lubricant of higher initial viscosity than oil, consisting originally of a calcium, sodium or lithium soap jelly emulsified with mineral oil.

Properties: Greases are a type of *shear-thinning* or pseudo-plastic fluid, which means that the viscosity of the fluid is reduced under shear. After sufficient force to shear the grease has been applied, the viscosity drops and approaches that of the base mineral oil (or that of the EP additive for EP greases under heavy load). This sudden drop in shear force means that grease is considered a plastic fluid, and the reduction of shear force with time makes it thixotropic. It is often applied using a grease gun.

Uses: Greases are employed where heavy pressures exist, where oil drip from the bearings is undesirable, and/or where the motions of the contacting surfaces are discontinuous so that it is difficult to maintain a separating lubricant film in the bearing. Grease-lubricated bearings have greater frictional characteristics at the beginning of operation. Under shear, the viscosity drops to give the effect of an oil-lubricated bearing of approximately the same viscosity as the base oil used in the grease. Calcium- and sodium-based greases are the most commonly used; sodium-based greases have higher melting point than calcium-based greases but are not resistant to the action of water. Lithium-based grease has a drip temperature at 190 to 220 C (350° to 400°F) and it resists moisture, hence it is commonly used as lubricant in household products such as garage door openers.

Additives: Teflon is added to some greases to improve their lubricating properties. Gear greases consist of rosin oil, thickened with lime and mixed with mineral oil, with some percentage of water. Special-purpose greases contain glycerol and sorbitan esters. They are used, for example, in low-temperature conditions. Some greases are labeled "EP", which indicates "extreme pressure". Under high pressure or shock loading, normal grease can be compressed to the extent that the greased parts come into physical contact, causing friction and wear. EP grease contains solid lubricants, usually graphite and/or molybdenum, to provide protection under heavy loadings. The solid lubricants bond to the surface of the metal, and prevent metal-to-metal contact and the resulting friction and wear when the lubricant film gets too thin.

Notes on Mobil Centaur Moly

(As an example of different EP Moly greases, from Mobil website)

Product Description: Mobil Centaur Moly is a premium quality grease formulated with advanced calcium sulfonate thickener technology. The calcium sulfonate thickener in the Mobil Centaur Moly products represents a significant advance in grease formulation technology. Unlike conventional soap-base thickeners (i.e. lithium, aluminum, and calcium soaps), the calcium sulfonate thickener does much more than simply impart consistency. It imparts excellent corrosion and water-resistance properties to the grease and has inherent extreme-pressure protection properties that enhance load-carrying ability. Further, the EP properties derived from the calcium thickener also have inherently better thermal stability than those from conventional Sulphur/Phosphorus EP additives. Fortified with molybdenum disulphide to complement its calcium sulfonate thickener extreme-pressure additive system.

Lithium-Based Grease

Lithium-based grease, often referred to simply as "lithium grease", is a lubricant grease to which lithium compounds have been added, giving it higher performance and temperature tolerance. Some formulations also include PTFE (Teflon) and/or other substances, such as molybdenum compounds.

Lithium grease adheres well to metal, is non-corrosive, and may be used under heavy loads. It has a drip temperature of 190° to 220°C (350° to 400°F) and it resists moisture, so it is commonly used as lubricant in household products, such as electric garage doors. Numerous types of grease thickeners are currently in use, each with its own pros and cons. The most common types are simple lithium soaps, lithium complex and polyurea.

Simple lithium soaps are often used in low-cost general-purpose greases and perform relatively well in most performance categories at moderate temperatures. Complex greases such as lithium complex provide improved performance particularly at higher operating temperatures. A common upper operating temperature limit for a simple lithium grease might be 250°F, while that for a lithium complex grease might be 350°F. Another thickener type that is becoming more popular is polyurea. Like lithium complex, polyurea has good high-temperature performance as well as high oxidation stability and bleed resistance. Thickener type should be selected based on performance requirements as well as compatibility when considering changing product types.

Grease Consistency and Thickener Type: The consistency of grease is controlled by the thickener concentration, thickener type and the viscosity of the base oil. Even though base oil viscosity affects consistency, it is important to note that a grease can have a high consistency and a low base oil viscosity or vice versa. The NLGI has established a scale to indicate grease consistency which ranges from grades 000 (semi-fluid) to 6 (block grease). The most common NLGI grade is two and is recommended for most applications.

Molybdenum disulfide

(better known simply as "Moly")

Molybdenum disulfide, also called molybdenum sulfide or molybdenum(IV) sulfide, with the formula **MoS_2**, is a black crystalline sulfide molybdenum It occurs as the mineral molybdenite. It is insoluble in water and un-reactive toward dilute acids. Its melting point is 1185 °C, but it starts oxidizing in air from 315 °C, limiting the range of its use as a lubricant in the presence of air between the temperatures of -185 and +350 °C; in non-oxidizing environments it is stable up to 1100 °C

The structure, appearance, and feel of molybdenum disulfide is similar to graphite - a sandwich of layers of molybdenum atoms between the layers of sulfur atoms. Due to the weak interactions between the sheets of sulfide atoms, MoS_2 has a lubricating effect. Finely powdered MoS_2 with particle sizes in the range of 1-100 µm is a common dry lubricant. It is also often mixed into various oils and greases, which allows the mechanisms lubricated by it to keep running for a while longer, even in cases of almost complete oil loss - finding an important use in aircraft engines.

MoS_2 grease is recommended for CV and universal joints.

It is also used as a lubricating additive to special plastics, notably nylon and Teflon.

During the Vietnam war, molybdenum disulfide, known as "dry slide", was used for lubricating troop's weapons; the military refused to supply it, as it was "not in the manual", so it was sent to soldiers by their parents and friends privately. Another application is for coating bullets, giving them easier passage through the rifle barrel with less deformation and better ballistic accuracy.

Carnauba wax

There is a common misconception that Carnauba wax and Japan wax are the same, they are not. Carnauba wax is derived from the leaves of a plant native to northeastern Brazil, the carnauba palm (*Copernicia prunifera*). It is known as "queen of waxes" and usually comes in the form of hard yellow-brown flakes. It is obtained from the leaves of the carnauba palm by collecting them, beating them to loosen the wax, then refining and bleaching the wax.

Carnauba wax can produce a glossy finish and as such is used in automobile waxes, shoe polishes and floor and furniture polishes, especially mixed with beeswax. It is used as a coating on dental floss. Use for paper coatings is the most common application in the United States. It is the main ingredient in surfboard wax, combined with coconut oil.

Carnauba wax is a prominent ingredient in bullet lubes as a hardener and keeps bores bright & shiny and cosmetic formulas, lipsticks, eyeliners, mascara, eye shadows, foundations, blushers, skin care preparations, sun care preparations, etc.

It is the finish of choice for most briar pipes. It produces a high gloss finish when buffed on to wood. This finish dulls with time rather than flaking off (as is the case with most other finishes used.)

In foods, it is used as a formulation aid, lubricant, release agent, and surface finishing agent in baked foods and mixes, chewing gum, confections, frostings, fresh fruits and juices, gravies, sauces, processed fruits and juices and soft candy.

It is also used in the pharmaceutical industry as a tablet coating agent.

Technical characteristics: INCI name is *Copernicia Cerifera (carnauba) wax*
E Number is E903.
Melting point: 78-85 °C, among the highest of natural waxes.
Relative density is about 0.97
It is among the hardest of natural waxes, being harder than concrete in its pure form.
It is practically insoluble in water, soluble on heating in ethyl acetate and in xylene, practically insoluble in ethyl alcohol.

Sodium Stearate

Sodium stearate is a chemical, the sodium salt of stearic acid and a major component of soap. It has the chemical formula $C_{17}H_{35}COONa$. Stearic Acid, also known as Stearin, increases the hardness and opacity of wax. It's use in bullet lube is as a stiffener plus it binds the ingredients together so they don't separate when cooling. Typical usage is 1-3 TBS per pound (2-5% by weight). Sodium Stearate can be ordered from candle & soap making suppliers. A simple source is shaving off slivers from a bar of Ivory soap. (See recipe for Felix lube below) Another good source of Stearic acid is tallow which contains roughly 14%.

Castor Oil

Castor oil is a vegetable oil obtained from the castor bean (or preferably *castor seed* as the castor plant, *Ricinus communis*, is not a member of the bean family).
Castor oil has an unusual composition and chemistry, which makes it quite valuable.

Ninety percent of fatty acids in castor oil are ricinoleic acid. Ricinoleic acid, a monounsaturated, 18-carbon fatty acid, has a hydroxyl functional group at the twelveth carbon, a very uncommon property for a biological fatty acid. This functional group causes ricinoleic acid (and castor oil) to be unusually polar, and also allows chemical derivitization that is not practical with other biological oils. Since it is a polar dielectric with a relatively high dielectric constant (4.7), highly refined and dried Castor oil is sometimes used as a dielectric fluid within high performance high voltage capacitors.

Castor oil maintains its fluidity at both extremely high and low temperatures. Sebacic acid is chemically derived from castor oil. Castor oil and its derivatives have applications in the manufacturing of soaps, lubricants, hydraulic and brake fluids, paints, dyes, coatings, inks, cold resistant plastics, waxes and polishes, nylon, pharmaceuticals and perfumes. In internal combustion engines, castor oil is renowned for its ability to lubricate under extreme conditions and temperatures, such as in air-cooled engines. The lubricants company Castrol takes its name from castor oil. However, castor oil tends to form gums in a short time, and its use is therefore restricted to engines that are regularly rebuilt, such as motorcycle race engines. Most drug stores carry Castor oil

The poison ricin is made from the byproducts in the manufacture of castor oil.

Lanolin

Lanolin, also called, Adeps Lanae, wool wax, wool fat, or wool grease, a greasy yellow substance from wool-bearing animals, acts as a skin ointment, water-proofing wax, and raw material (such as in shoe polish).

Lanolin is "wool fat" or grease , chemically akin to wax. It is produced by wool-bearing animals such as sheep, and is secreted by their sebaceous glands. These glands are associated with hair follicles. Lanolin acts as a waterproofing wax, and recent studies indicate that antibiotics are also present in the lanolin. It aids sheep in shedding water from their coats. Certain breeds of sheep produce large amounts of lanolin, and the extraction can be performed by squeezing the wool between rollers. Most or all the lanolin is removed from wool when it is processed into textiles e.g. yarn or felt.

Lanolin is chiefly a mixture of cholesterol and the esters of several fatty acids. Crude (non-medical) grades of lanolin also contain wool alcohols, which are an allergen for some people. It is insoluble in water, but forms an emulsion.

Lanolin is used commercially in a great many products ranging from rust-preventative coatings to cosmetics to lubricants. Some sailors use lanolin to create a slippery surface on their propellers and stern gear to which barnacles cannot adhere. Its water-repellent properties make it valuable as a lubricant grease where corrosion would otherwise be a problem, particularly on stainless steel, which becomes vulnerable to corrosion when starved of oxygen.

Using cosmetic products which contain too much lanolin can result in an allergic reaction to the chemical in some people.

Medical grade lanolin is used as a cream to soothe skin. Lansinoh cream, a product that some breastfeeding mothers use on sore and cracked nipples, is pure, hypoallergenic, bacteriostatic medical grade lanolin. This grade of lanolin can also be used to treat chapped lips, diaper rash, dry skin, itchy skin, rough feet, minor cuts, minor burns and skin abrasions. As an ointment basis, it readily absorbs through skin, facilitating absorption of the medicinal chemicals it carries. Lanolin is often used as a raw material for producing vitamin D3.

The name Lanolin comes from a trademark that became known as the generic term for a preparation of sheep fat and water. Jaffe v. Evans & Sons, Ltd., Supreme Court, Appellate Division, First Department, New York (March 21, 1902).

Paraffin wax

Paraffin is a common name for a group of alkane hydrocarbons discovered by Carl Reichenbach. In the U.S.A. the fuel known in most of the world as paraffin oil (or just *paraffin*) is called kerosene. The solid forms of paraffin are called paraffin wax. **Paraffin** is also a technical name for an alkane in general, but in most cases it refers specifically to a linear, or *normal* alkane, while branched, or *iso*alkane are also called *iso*paraffins. The name is derived from the Latin *parum* (= barely) + *affinis* with the meaning here of "lacking affinity", or "lacking reactivity").

Physical and chemical properties: It is mostly found as a white, odorless, tasteless, waxy solid, with a typical melting point between about 47 °C and 65 °C. It is insoluble in water, but soluble in ether, benzene, and certain esters. Paraffin is unaffected by most common chemical reagents, but burns readily. Pure paraffin is an extremely good electrical insulator, with a electrical resistivity of 10 ohm meter. This is better than nearly all other materials except some plastics (notably Teflon).

Liquid paraffin has a number of names, including nujol, mineral spirits, adepsine oil, alboline, glymol, liquid paraffin, paraffin oil, saxol, or **USP mineral oil**. Jet fuel is a type of paraffin oil (or "kerosene" in US English).

In some bullet lubes it is used to stiffen or harden the lube. Paraffin wax is often used to seal the jars when canning fruits and vegetables and can be found in most grocery stores.

Mineral oil

Mineral oil (baby oil) or **liquid petrolatum** is a by-product in the distillation of petroleum to produce gasoline. It is a chemically inert, transparent, colorless oil composed mainly of alkanes and ***cyclic paraffins***, related to white petrolatum. Mineral oil is a substance of relatively low value, and it is produced in very large quantities. Mineral oil is available in light and heavy grades, and can often be found in drug stores.

Japan wax

There is a common misconception that Japan wax and Carnauba wax are the same, they are not. **Japan wax** is a pale-yellow, waxy, water-insoluble solid with a gummy feel, obtained from the berries of certain sumacs native to Japan and China, such as Rhus verniciflua (Japanese sumac tree) and Rhus succedanea (Japanese wax tree).
Japan wax is a byproduct of lacquer manufacture. It is not a true wax but a fat that

contains 10-15% palmitin, stearin, and olein with about 1% japanic acid. Japan wax is sold in flat squares or disks and has a rancid odor. It is extracted by expression and heat, or by the action of solvents.

Uses: Japan wax is used chiefly in the manufacture of candles, furniture polishes, floor waxes, wax matches, soaps, food packaging, pharmaceuticals, cosmetics, pastels, crayons, buffing compounds, metal lubricants, adhesives, thermoplastic resins, and as a substitute for beeswax. **Other Names:** Japan tallow; sumac wax; sumach wax; vegetable wax.

Properties: Melting point =53°C.
Soluble in benzene, ether, naphtha and alkalis. Insoluble in water or cold ethanol.
Iodine value=4.5-12.6.
Acid value=6-209.
Saponification value=206.5-237.5.

Motor Mica

Motor Mica: No info found other than as a brand name of "*Scientific Lubricants Company*", Carpentersville, Ill 60110 and sold as an anti-friction and heat resisting, dry powder lube. Forster sells it as a dry case neck lube. No melting point listed. Non-toxic. Recommended use as additive: 2oz per pound of lubricant. No current info or web site was found for *Scientific Lubricants Company*, Carpentersville, Ill.

The mica group of sheet silicate (phyllosilicate) minerals includes several closely related materials having highly perfect basal cleavage. All are monoclinic with a tendency towards pseudo-hexagonal crystals and are similar in chemical composition. The highly perfect cleavage, which is the most prominent characteristic of mica, is explained by the hexagonal sheet-like arrangement of its atoms.

Canola Oil

Canola was developed through conventional plant breeding from rapeseed, an oilseed plant with roots in ancient civilization. The word "rape" in rapeseed comes from the Latin word "*rapum*," meaning turnip. Turnip, rutabaga, cabbage, Brussels sprouts, mustard and many other vegetables are related to the two canola species commonly grown: *Brassica napus* and *Brassica rapa*.

Its use was limited until the development of steam power, when machinists found rapeseed oil clung to water and steam-washed metal surfaces better than other lubricants. World War II saw high demand for the oil as a lubricant for the rapidly increasing number of steam engines in naval and merchant ships. Canola oil is a promising source for manufacturing biodiesel, a renewable alternative to fossil fuels. Compared with sunflower, corn, peanut, and many other oils, Canola has a low ratio of saturated to unsaturated fat. dubbed Canola, from **Can**adian **O**il **L**ow **A**cid.

Olive Oil

In bullet lube or as lead alloy flux (mixed with sawdust)

<Caution: Highly Flammable>

Olive oil is a vegetable oil obtained from the olive (*Olea europaea* L.), a traditional tree crop of the Mediterranean Basin. It is used in cooking, cosmetics, soaps and as a fuel for traditional oil lamps. Olive oil is regarded as a healthful dietary oil because of its high content of monounsaturated fat (mainly oleic acid) and polyphenols.

The International Olive Oil Council (IOOC) sets standards of quality used by the major olive oil producing countries. It officially governs 95 percent of international production, and holds great influence over the rest. IOOC terminology is precise, but it can lead to confusion between the words that describe production and the words used on retail labels. Olive oil is classified by how it was produced, by its chemistry, and by its flavor. All production begins by transforming the olive fruit into olive paste. This paste is then malaxed to allow the microscopic oil droplets to concentrate. The oil is extracted by means of pressure (traditional method) or centrifugation (modern method). After extraction the remnant solid substance, called *pomace*, still contains a small quantity of oil.

Industrial grades: The several oils extracted from the olive fruit can be classified as: *Virgin* means the oil was produced by the use of physical means and no chemical treatment. The term *virgin oil* referring to production is different from *Virgin Oil* on a retail label.

Refined means that the oil has been chemically treated to neutralize strong tastes (characterized as defects) and neutralize the acid content (free fatty acids). Refined oil is commonly regarded as lower quality than virgin oil; the retail labels *extra-virgin olive oil* and *virgin olive oil* cannot contain any refined oil.
Pomace olive oil means oil extracted from the pomace using chemical solvents — mostly hexane — and by heat.

Quantitative analytical methods determine the oil's acidity, defined as the percent, measured by weight, of free oleic acid in it. This is a measure of the oil's chemical degradation — as the oil degrades, more fatty acids get free from the glycerides, increasing the level of free acidity. Another measure of the oil's chemical degradation is the peroxide level, which measures the degree to which the oil is oxidized (rancid).

To use olive oil as an alloy flux place sawdust in a plastic sandwich bag and shake the bag until mixed, use only enough olive oil to dampen the sawdust. Use caution and use **only outdoors**, this mix is highly flammable but it is a good flux. Many, including myself, dispute that olive oil in sawdust is an improved flux over sawdust alone. Sawdust as a flux is highly effective. See the book: From Ingot to Target: A Cast Bullet Guide for Handgunners Chapter 4, Fluxing.

Retail grades: Extra-virgin olive oil comes from the first pressing of the olives, contains no more than 0.8% acidity, and is judged to have a superior taste. There can be no refined oil in extra-virgin olive oil.

Virgin olive oil with an acidity less than 2%, and judged to have a good taste. There can be no refined oil in virgin olive oil. Olive oil is a blend of virgin oil and refined virgin oil, containing at most 1% acidity. It commonly lacks a strong flavor.

Olive-pomace oil is a blend of refined pomace olive oil and possibly some virgin oil. It is fit for consumption, but it may not be called *olive oil*. Olive-pomace oil is rarely found in a grocery store; it is often used for certain kinds of cooking in restaurants.

Lampante oil is olive oil not used for consumption; *lampante* comes from olive oil's ancient use as fuel in oil-burning lamps. Lampante oil is mostly used in the industrial market.

Teflon

Teflon: Due to its low friction, it is used for applications where sliding action of parts is needed: bearings, bushings, gears, slide plates, etc. In these applications it performs significantly better than nylon and acetal; it is comparable with ultra high molecular weight polyethylene (UHMWPE), although UHMWPE is more resistant to wear than Teflon. For these applications, versions of teflon with mineral oil or molybdenum disulfide embedded as additional lubricants in its matrix are being manufactured.

Polytetrafluoroethylene (**PTFE**) is a fluoropolymer discovered by Roy J. Plunkett (1910–1994) of DuPont in 1938. It was introduced as a commercial product in 1946 and is generally known to the public by DuPont's brand name Teflon.

PTFE has the lowest coefficient of friction (against polished steel) of any known solid material. It is used as a non-stick coating for pans and other cookware. PTFE is very non-reactive, and so is often used in containers and pipework for reactive chemicals. According to DuPont its melting point is 327 °C, but its properties degrade above 260 °C.

Other polymers with similar composition are known with the *Teflon* name: fluorinated ethylene-propylene (FEP) and perfluoroalkoxy polymer resin (PFA). They retain the useful properties of PTFE of low friction and non-reactivity, but are more easily formable. FEP is softer than PTFE and melts at 260 °C; it is highly transparent and resistant to sunlight.

History: PTFE is sometimes said to be a spin-off from the U.S. space program with more down-to-earth applications; this is an urban legend, as Teflon cooking pans were commonplace before Yuri Gagarin's flight in 1961. PTFE was discovered serendipitously by Roy Plunkett of DuPont in 1938, while attempting to make a new CFC refrigerant, when the perfluorethylene polymerized in its storage container. DuPont patented it in 1941, and registered the Teflon trademark in 1944.

An early advanced use was in the Manhattan Project, as a material to coat valves and seals in the pipes holding highly-reactive uranium hexafluoride in the vast uranium enrichment plant at Oak Ridge, Tennessee, when it was known as **K416**.

It was first sold commercially in 1946 and by 1950, DuPont was producing over a million pounds (450 t) per year in Parkersburg, West Virginia. In 1954, French engineer Marc Grégoire created the first Teflon-coated cooking pan.

Teflon has been supplemented with another DuPont product, Silverstone, a three-coat fluoropolymer system that produces a more durable finish than Teflon. Silverstone was released in 1976.

Amongst many other industrial applications, PTFE is used to coat certain types of hardened, armour-piercing bullets in the military and in civilian use to reduce the amount of wear on the firearm's rifling in expensive match grade barrels. These are often mistakenly referred to as "cop-killer" bullets on account of PTFE's supposed ability to ease a bullet's passage through body armour. Any armour-piercing effect is, however, purely a function of the bullet's velocity, rigidity, nose shape and weight rather than any property of PTFE. Teflon coated bullets as a "cop killer" round is a 100% media generated myth.

Properties and applications: PTFE has excellent dielectric properties. This is especially true at high radio frequencies, making it eminently suitable for use as an insulator in cables and connector assemblies and as a material for printed circuit boards used at microwave frequencies. Combined with its high melting temperature, this makes it the material of choice as a high performance substitute for the weaker and more meltable polyethylene that is commonly used in low-cost applications. Its extremely high bulk resistivity makes it an ideal material for fabricating long life electrets, useful devices that are the electrostatic analogues of magnets.

Due to its low friction, it is used for applications where sliding action of parts is needed: bearings, bushings, gears, slide plates, etc. In these applications it performs significantly better than nylon and acetal; it is comparable with ultra high molecular weight polyethylene (UHMWPE), although UHMWPE is more resistant to wear than Teflon. For these applications, versions of teflon with mineral oil or molybdenum disulfide embedded as additional lubricants in its matrix are being manufactured.

Because of its chemical inertness, PTFE cannot be cross-linked like an elastomer. Therefore it has no "memory", and is subject to creep (also known as **cold flow** and **compression set**). This can be both good and bad. A little bit of creep allows PTFE seals to conform to mating surfaces better than most other plastic seals. Too much creep, however, and the seal is compromised. Compounding fillers are used to control unwanted creep, as well as to improve wear, friction, and other properties.

Gore-Tex is a material incorporating teflon membrane with micropores. The roof of the Hubert H. Humphrey Metrodome in Minneapolis is the largest application of Teflon on Earth, using 20 acres of the material in a double-layered white dome, made with PTFE-coated fiberglass that gives the stadium its distinctive appearance.

Powdered PTFE is used in pyrotechnic compositions as oxidizer together with powdered metals such as aluminum and magnesium. Upon ignition these mixtures form carbonaceous soot and the corresponding metal fluoride and release large amounts of heat. Hence they are use as infrared decoy flares and igniters for solid fuel rocket propellants.

Tallow (See also Lard)

Tallow is a rendered form of beef or mutton fat, processed from suet. It is solid at room temperature. Unlike suet, tallow can be stored for extended periods without the need for refrigeration to prevent decomposition, provided it is kept in an airtight container to prevent oxidation.

Rendered fat obtained from pigs is known as *lard*.

Industrially, tallow is not strictly defined as beef or mutton fat. In this context, tallow is animal fat that conforms to certain technical criteria, including its melting point, which is also known as titre. It is common for commercial tallow to contain fat derived from other animals, such as pigs or even from plant sources.

Tallow is used in animal feed, to make soap, for cooking, and as a bird food. It can be used as a raw material for the production of biodiesel and other oleochemicals. Historically, it was used to make tallow candles, which were a cheaper alternative to wax candles.

Tallow is used in the steel rolling industry to provide the required lubrication as the sheet steel is compressed through the steel rollers. There is a trend towards replacing tallow based lubrication with synthetic oils in rolling applications for surface cleanliness reasons.

Tallow can also be used as flux for soldering. (see notes on flux below) Tallow is also the primary ingredient in some leather conditioners.

The use of tallow or lard to lubricate rifles was the spark that started the Indian Rebellion of 1857. To load the new Pattern 1853 Enfield Rifle, the sepoys had to bite the cartridge open. It was believed that the paper cartridges that were standard issue with the rifle were greased with lard (pork fat) which was regarded as unclean by Muslims, or tallow (beef fat), regarded as sacred to Hindus.

Tallow, along with beeswax, was also used in the creation of lubricant for American Civil War ammunition used in the Springfield Rifle Musket.

Mobil Dexron-VI ATF

(Automatic transmission fluid)
(from Mobil web site)

Mobil DEXRON-VI ATF is a high performance, synthetic blend automatic transmission fluid formulation.
Improved oxidation and thermal stability.
Optimized frictional properties during low temperature.
Outstanding resistance against sludge and deposit formation.
Improved anti-wear protection.

Vaseline® Petroleum Jelly

Vaseline® (petroleum jelly) is a mixture of mineral oils, paraffin and microcrystalline waxes.

Petroleum jelly is a flammable, semi-solid mixture of hydrocarbons, having a melting-point usually ranging from a little below to a few degrees above 167°F (75°C). It is colorless, or of a pale yellow color (when not highly distilled), translucent, and devoid of taste and smell when pure. It does not oxidize on exposure to the air, and is not readily acted on by chemical reagents. It is insoluble in water. There is a common misconception (resulting from the similar feel they produce when applied to human skin) that petroleum jelly and glycerol (glycerine) are physically similar. While petroleum jelly is a non-polar hydrocarbon *hydrophobic* (water-repelling) and insoluble in water, glycerol (not a hydrocarbon but an alcohol) is the opposite: it is so strongly *hydrophilic* (water-attracting) that by continuous absorption of moisture from the air, it produces the feeling of wetness on the skin.

Crisco

Crisco is a brand of shortening, it was first produced in 1911 by Procter & Gamble and was the first shortening to be made entirely of vegetable oil.

Chemist Edwin C. Kayser (Procter & Gamble) developed the process to hydrogenate cottonseed oil, which ensures the shortening remains solid at normal storage temperatures. The initial purpose was to create a cheaper substance to make candles than the expensive animal fats in use at the time.

In April 2004, Crisco Zero Grams Trans Fat was introduced which contained fully hydrogenated palm oil blended with liquid vegetable oils to yield a shortening much like the original Crisco. As of January 24, 2007, all Crisco shortening products have been reformulated. The separately marketed trans-fat free version introduced in 2004 was discontinued. Crisco now consists of a blend of soybean oil, fully hydrogenated cottonseed oil, and partially hydrogenated soybean and cottonseed oils.

Historical battle re-enactors sometimes use Crisco as a lubricating agent for musket balls, to retard the effects of black powder residue.

Cosmoline

Cosmoline is the trade name for a generic class of rust preventatives, conforming to MIL-C-11796C Class 3, that are a brown colored wax-like mass; have a slight fluorescence; and have a petroleum-like odor and taste.

Chemically, Cosmoline is a homogeneous mixture of oily and waxy long-chain, non-polar hydrocarbons. It is always brown in color, and can differ in viscosity and shear strength. Cosmoline melts at 130-150 °F (45–52 °C) and has a flashpoint of 365 °F (185 °C).

Its most common use is in the storage and preservation of firearms. Previously, Cosmoline was used to preserve other items. Objects the size of entire vehicles could be preserved for future use with Cosmoline.

Due to its gelatinous nature, Cosmoline can be difficult to remove completely from firearms.

Soy wax

Soy wax is a partially-hydrogenated form of soybean oil. It is typically softer than paraffin wax and with a lower melting temperature, in most combinations. However, other additives by producers can raise this melt point. Soy wax is available in flake and pellet form and has an off-white, opaque appearance. Its lower melting temperature can mean hot weather can deform candles.

Some soy candles are made up of a blend of different waxes, including beeswax, paraffin, or palm wax.

Candle making additives that are sometimes used in soy candle making include: stearic acid, mineral oil, petrolatum, luster crystals, dye/pigment, fragrance (natural or artificial), synthetic wax, ultraviolet absorbers, and bht crystals.

Standard labeling of soy candles is not enforced, therefore any claims to benefits to this candle are not regulated. Using soy wax is a choice as there are studies that claim to its medical preference over other waxes with heavy use of candles.

Bayberry wax

Bayberry wax is an aromatic green vegetable wax. It is removed from the surface of the fruit of the bayberry (wax-myrtle) shrub *Myrica faya* by boiling the fruits in water and skimming the wax from the surface of the water. It is made up primarily of esters of lauric, myristic, and palmitic acid. Melting point = 45 °C.

Bayberry wax is used primarily in the manufacture of candles and other products where the distinctive fragrance is desirable.

Alox

Still searching for valid, useful information on Alox. The original Alox company of Niagara Falls, NY made the original Alox 2138F used by Col. E. H. Harrison of the NRA Technical staff to develop the NRA formula of Alox lube. 2138F was dropped from the company's product list when the company was sold. I have read many times that the Lubrizol company is the current producer of Alox but their web site lists nothing of any Alox products. There is an Alox Corporation in Brazil that lists several Alox products but not 2138F and not the stated replacement product Alox 350. Col. Harrison's writing indicates he tested 350 and discontinued it's use because of to low a melting point for bullet lube.

The commercial bullet lube maker Javelina still lists the original NRA formula of 50/50 yellow beeswax and Alox 2138F as available. This is a bit puzzling considering it's nearly 50 years since 2138F has been manufactured. Lee markets "Lee Liquid Alox (LLA)" as a liquid lube for their tumble lube bullets but which Alox or it's source is unknown.

STP Oil Treatment

An oil conditioning additive, STP is a brand name and trade name for the automotive additives and performance division of the Clorox Corporation.

Founded in 1953 in Saint Joseph, Missouri, the company’s name, *STP*, was derived from

"Scientifically Treated Petroleum". The company entered into the marketplace with one product, STP Oil Treatment.

In 1961 the company was acquired by the Studebaker-Packard Corporation. Studebaker briefly tied STP into its advertising as an abbreviation for "Studebaker Tested Products".

In 1976 STP faced a consumer protection order that required it to have scientific backing for certain statements and prohibited making false claims. In 1978 it paid a $500,000 civil penalty over claims, and in 1995 it paid $888,000 to settle Federal Trade Commission charges of false advertising.

Aside from the charges of false advertising one of the "claims" made by STP is that it leaves a "thicker" film of oil between moving metal parts, if true this "could" make it useful in bullet lube formulas in helping to seal bore imperfections and reduce gas blow by.

Peanut oil

The peanut, or groundnut (*Arachis hypogaea*), is a species in the legume family (Fabaceae) native to South America, Mexico and Central America. Peanut oil (*arachis* oil) is an organic material oil derived from peanuts, noted to have the slight aroma and taste of its parent legume. Its major component fatty acids are oleic acid (56.6%) and linoleic acid (26.7%). The oil also contains some palmitic acid, arachidic acid, arachidonic acid, behenic acid, lignoceric acid and other fatty acids. Peanut oil could be used as a source of fuel for the diesel engine. It is also used as the main ingredient in some ear-wax removing products.
Peanut oil is appreciated for its high smoke point relative to many other cooking oils.

Peanuts are known by many local names, including earthnuts, ground nuts, goober peas and monkey nuts; the last of these is often used to mean the entire pod.

Steam cylinder oil

Steam oil is often referred to as cylinder oil and compounded steam cylinder oil as its primary use is to lubricate the valves and cylinders of steam engines. Steam cylinder oil provides a lubricating film to the engine steam admission valves (D-shaped valves in a Stanley engine) and the pistons within the cylinder walls. Both the valves and the pistons are metal to metal sliding interfaces. Steam oil must possess unique characteristics to allow it to mix with superheated steam, saturated steam, and hot water (condensate). Steam oils are manufactured primarily from mineral oils and are of viscosities equal to or greater than 600-weight oils.

Heating raw petroleum collected from oil wells and drawing off the vaporized gasses at different temperatures provides various products such as gasoline, kerosene, and diesel fuels as well as lubricating oils also known as mineral oils. Water will displace most oils, with the exception of animal based oils, and consequently special compounded oils that will lubricate in the presence of water are needed for successful steam engine operation. Modern steam oils contain 4% tallow by volume that comes from animals. Animal oil based tallow is produced by heating or boiling animal carcasses, and collecting the liquid residue. It is this tallow oil that makes steam oil work in the hostile internal environment of the steam engine. In practice the petroleum producers place several compounds in steam oil to help stabilize viscosity and lubricity; hence the name compounded steam oil. Steam oils are manufactured in several blends depending on the temperature of the steam they are to be used with.

Jojoba oil

Jojoba oil (pronounced "ho-HO-bah") is the liquid wax produced in the seed of the jojoba (*Simmondsia chinensis*) plant, a shrub native to southern Arizona, southern California and northwestern Mexico. The oil makes up approximately 50% of the jojoba seed by weight.

Unrefined jojoba oil appears as a clear golden liquid at room temperature with a slightly fatty odor. Refined jojoba oil is colorless and odorless. The melting point of jojoba oil is approximately 10°C and the iodine value is approximately 80. Jojoba oil is relatively shelf-stable when compared with other vegetable oils. It has an Oxidative Stability Index of approximately 60, which means that it is more shelf-stable than oils of safflower oil, canola oil, almond oil or squalene but less than castor oil, macadamia oil and coconut oil.

Most jojoba oil is consumed as an ingredient in cosmetics and personal care products. Jojoba oil is also used as a replacement for whale oil and its derivatives, such as cetyl alcohol. The ban on importing whale oil to the US in 1971 led to the discovery that it is "in many regards superior to sperm oil for applications in the cosmetics and other industries." Jojoba biodiesel has been explored as a cheap, sustainable fuel that can serve as a substitute for petroleum diesel.

Johnsons Paste Wax

By weight: Isoparaffinic hydrocarbon solvent 75-85%, Paraffin wax 10-30%, Carnauba Wax 5-10%.

Used as a finished wood wax, also on bare metal to retard rust. Used in bullet lube blended with various lube ingredients and alone as lube. There are several good discussions on Johnsons Paste Wax as bullet lube at "CastBoolits.com", use the search function and type in Johnsons Paste Wax.

Ballistol

Ballistol (meaning 'Ballistic Oil') is a mineral oil-based chemical which advertises that it has many uses. It was originally intended for cleaning, lubricating, and protecting firearms. The product originated from Germany before World War II, after the military requested an 'all-around' oil and cleaner for their rifles and equipment.

The chemical is a yellowish clear liquid with a consistency expected of a light oil. However, when it comes in contact with water it emulsifies, becoming a thick creamy white substance. It has a sweet and mildly pungent smell similar to black licorice. It is distributed in liquid and aerosol forms. The aerosol uses butane or propane as a propellant.

One of its selling points is that it is not petro-chemical based, and uses biodegradable ingredients. It also advertises it has no carcinogens. Some other similar chemicals contain petro-chemicals which can damage the 'seasoning' developed on the bore of a black-powder gun.

Advertisements for Ballistol claim that it dissolves traces of copper, lead, brass, zinc & tombac.

Acheson's graphite #1340

Solid lubricants. Several kinds of solid materials are used for lubricating purposes, such as graphite, talc, soapstone, mica, flowers of sulphur, white lead. Some of these solid lubricants, such as flake graphite or mica, possess a tough, flaky, foliated structure which enables them to resist pressure without disintegration. Others, such as amorphous graphite or flowers of sulphur, are easily crushed into a fine powder when exposed to pressure.

Graphite is the most important of all solid lubricants. It is not altered in constitution by temperature and is remarkably resistant to the action of acids. It is not attacked by alkalis. The greater part of the world's supplies of natural graphite come from Austria, Ceylon, Italy, Bavaria, Madagascar, the United States, Canada, Mexico, Japan, Siberia and England. Natural graphite, as it is obtained from the graphite mines, contains some impurities, chiefly silica, alumina and ferric oxides.

Flake graphite may either be used dry, or in admixture with semi-solid lubricants. It cannot be used mixed with oil in ordinary lubricators or lubricating systems, because of its high specific gravity, which causes it to separate out and choke lubricators, oil pipes and oil grooves.

Artificial Graphite. Amorphous graphite is produced artificially by Dr, Acheson in the electrical furnace. He is able by his process to produce graphite of a soft unctuous non-coalescing nature and almost chemically pure.

The varieties produced for lubricating purposes are guaranteed to contain 99 per cent, of pure carbon, but usually contain more. In one variety of graphite, No. 1340, 98 per cent, of the graphite particles are less than 3^ in. in diameter. From this or similar graphite Dr. Acheson produces what he calls deflocculated graphite by kneading it for a long time with water in the presence of a vegetable extract, such as tannic acid; the graphite particles in this process disintegrate into particles one thousand times less in diameter, in fact, Dr. Acheson estimates that each particle of the "1340" graphite becomes divided into 700,000 particles, a smallness of size bordering on the molecular, and the graphite becomes diffused in the water in colloidal form.

Neatsfoot Oil

Fat from warm-blooded animals normally has a high melting point, becoming hard when cool – but neatsfoot oil remains liquid at room temperature. This is because the relatively slender legs and feet of animals such as cattle are adapted to tolerate and maintain much lower temperatures than those of the body core, using counter current heat exchange in the legs between warm arterial and cooler venous blood – other body fat would become stiff at these temperatures. This characteristic of neatsfoot oil allows it to soak easily into leather.

Modern neatsfoot oil is sometimes made from lard. It is sold as neatsfoot oil in pure form. If mineral oil or other petroleum-based material is added, the product may be called "neatsfoot oil compound". Some brands have also been shown to be adulterated with rapeseed oil, soya oil, and other oils. The addition of mineral oils may lead to more rapid decay of non-synthetic stitching or speed breakdown of the leather itself

Neatsfoot oil is used on a number of leather products, although it has been replaced by synthetic products for certain applications. Items such as baseball gloves, saddles, horse harnesses and other horse tack can be softened and conditioned with neatsfoot oil.

If used on important historical objects, neatsfoot oil (like other leather dressings) can oxidize with time and actually contribute to embrittling. It also may leave an oily residue that can attract dust. On newer leather, it may cause darkening (even after a single application), and thus may not be a desirable product to use when the maintenance of a lighter shade is desired. Neatsfoot oil is more useful for routine use on working equipment.

Murphy's Oil Soap

Despite the name, oil soap does not contain oil; it contains potassium soap manufactured from vegetable oil. The other constituents of Murphy Oil Soap are sodium EDTA, propylene glycol, fragrance, surfactants, and water. Complete Solubility In Water.

Oil soap is commonly used to clean and polish horse tack, such as bridles and saddles. The oil soap is also an excellent lubricant to use with water when throwing clay on a potter's wheel.

Lard (see also Tallow)

Lard is pig fat in both its rendered and un-rendered forms. Lard can be obtained from any part of the pig as long as there is a high concentration of fatty tissue. The highest grade of lard, known as leaf lard, is obtained from the "flare" visceral fat deposit surrounding the kidneys and inside the loin. The next highest grade of lard is obtained from fatback, the hard subcutaneous fat between the back skin and muscle of the pig. The lowest grade (for purposes of rendering into lard) is obtained from the soft caul fat surrounding digestive organs, such as small intestines. Lard is one of the few edible oils with a relatively high smoke point, pure lard is especially useful for cooking since it produces little smoke when heated.

Note: If you purchase lard be certain that NO salt has been added.

Bullplate

Bullplate is a product sold by the Bull Shop in Alaska as a mould and sprue plate lubricant and is the key ingredient in Speed Green bullet lube. Bullplate and Speed Green are spoken very highly of by experienced bullet casters and can be ordered online @ http://bullshop.gunloads.com/

Graphite

The mineral graphite is one of the allotropes of carbon. Unlike diamond (another carbon allotrope), graphite is an electrical conductor, a semimetal, and can be used, for instance, in the electrodes of an arc lamp. Graphite holds the distinction of being the most stable form of carbon under standard conditions. Therefore, it is used in thermochemistry as the standard state for defining the heat of formation of carbon compounds. Graphite may be considered the highest grade of coal.

There are three principal types of natural graphite, each occurring in different types of ore deposit:

1> Crystalline flake graphite (or flake graphite for short) occurs as isolated, flat, plate-like particles with hexagonal edges if unbroken and when broken the edges can be irregular or angular;

2> Amorphous graphite occurs as fine particles and is the result of thermal metamorphism of coal, the last stage of coalification, and is sometimes called meta-anthracite. Very fine flake graphite is sometimes called amorphous in the trade;

3> Lump graphite (also called vein graphite) occurs in fissure veins or fractures and appears as massive platy intergrowths of fibrous or acicular crystalline aggregates, and is probably hydrothermal in origin.

Graphite and graphite powder are valued in industrial applications for its self-lubricating and dry lubricating properties. Natural graphite is mostly consumed for refractories, steelmaking, expanded graphite, brake linings, and foundry facings-lubricants. Pencils use graphite, not lead.

Microcrystalline wax

Microcrystalline waxes are a type of wax produced by de-oiling petrolatum, as part of the petroleum refining process. In contrast to the more familiar paraffin wax which contains mostly unbranched alkanes, microcrystalline wax contains a higher percentage of isoparaffinic (branched) hydrocarbons and naphthenic hydrocarbons. It is characterized by the fineness of its crystals in contrast to the larger crystal of paraffin wax. It consists of high molecular weight saturated aliphatic hydrocarbons. It is generally darker, more viscous, denser, tackier and more elastic than paraffin waxes, and has a higher molecular weight and melting point. The elastic and adhesive characteristics of microcrystalline waxes are related to the non-straight chain components which they contain. Typical microcrystalline wax crystal structure is small and thin, making them more flexible than paraffin wax. It is commonly used in cosmetic formulations.

Microcrystalline waxes when produced by wax refiners are typically produced to meet a number of ASTM specifications. These include congeal point (ASTM D938), needle penetration (D1321), color (ASTM D6045), and viscosity (ASTM D445). Microcrystalline waxes can generally be put into two categories: "laminating" grades and "hardening" grades. The laminating grades typically have a melt point of 140-175 F and needle penetration of 25 or above. The hardening grades will range from about 175-200 F, and have a needle penetration of 25 or below. Color in both grades can range from brown to white, depending on the degree of processing done at the refinery level.

Microcrystalline waxes are derived from the refining of the heavy distillates from lubricant oil production. This by product then must be de-oiled at a wax refinery. Depending on the end use and desired specification, the product then may have its odor removed and color removed (which typically starts as a brown or dark yellow). This is usually done by means of a filtration method or by hydro-treating the wax material.

Microcrystalline wax is often used in industries such as the tire and rubber, candles, adhesives, corrugated board, cosmetics, castings, and a host of others. Refineries may also utlize blending facilities to combine paraffin and microcrystalline waxes. This type of activity is prevalent especially for industries such as tire and rubber.

Microcrystalline waxes are excellent materials to use when modifying the crystalline properties of paraffin wax. The microcrystalline wax has a significant effect on the branching of the carbon chains that are the backbone of paraffin wax. This is useful when some desired functional changes in the paraffin are needed, such as flexibility, higher melt point, and increased opacity.

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Your now ready to put on your wizard's hat and start your quest for the perfect bullet lube. This section gives several lube recipes that others have "cooked up", many of them are very effective. Use these recipes or the above ingredients to test your own ideas.

Col. E. H. Harrison of the NRA Technical staff after conducting extensive lube tests wrote, *It's very easy to create a lube that prevents leading but lube effects accuracy. The final test of evaluating a lube has to be by shooting and evaluating groups.* My own lube experiments confirm this. I made up over a dozen different lubes and fired groups at 150 meters. I used my 308 Winchester with a known load that uses LBT blue lube as a standard to compare to. None of the lubes tested caused any leading in this rifle but accuracy was effected with each of them.

Bullet Lube Recipes

Felix Lube (By Felix Robbins)

You can equal or surpass Veral's lube (LBT Blue) with beeswax, anhydrous lanolin, mineral oil, Sodium Stearate, castor oil, and paraffin. On the stove using a shallow pot, heat two tablespoons of baby oil (mineral oil). When starting to smoke, add a tablespoon of castor oil and raise to just below smoking (about 300 degrees) and continually stir for around an half hour. After the time is up, add slivers of Ivory soap (sodium stearate), making the slivers melt entirely by stirring one parcel before adding more. Use a razor blade to make the slivers, and saturate the mixture with the soap, but no more than a tablespoon's worth. Then add one tablespoon of lanolin. After mixing, add beeswax to make the final mixture per requirement. Add paraffin to the batch to make it a harder pan lube when beeswax is scarce. A special ingredient which impresses friends is Carnauba wax. It's not required to do the job, but it keeps your barrel mirror bright after each shot. Now here comes a little more info: **beeswax is the base, castor oil is the real lube, lanolin makes the lube sticky, stearate glues the mess together so it does not separate into components upon cooling, carnauba wax adds the shine, and paraffin is the ultimate hardener**, to be used as a last resort... add more castor oil or lanolin to make the lube slicker *for smaller bores and/or a winter lube* . . . Always slick the barrel down with Hoppy's or other oily cleaner and then dry patch it with only one push-thru stroke before shooting... felix

Favorite Lube of Glen E. Fryxell

Mixed 50/50 *by weight*: Lithium Moly wheel bearing grease and bees wax.

NRA Formula

By weight: 50/50 pure yellow beeswax and Alox 2138F, developed by Col. E. H. Harrison and printed in "The Rifleman", reprinted in The NRA Cast Bullet book (currently out of print). Alox 2138F is no longer made but there are substitute Alox formulas being used.

NOTE: It is often stated the original NRA Alox formula contained paraffin and/or other ingredients, this is false. In Col. E. H. Harrison own words and printed in The NRA Cast Bullet book . . . quote: *The composition of one part Alox 2138F and one part pure yellow beeswax means that, not something else.* End quote.

Col. Harrison did extensive lube testing in the 50's and 60's and came to the conclusion that making a lube that prevents or minimizes leading was fairly easy, making a lube that permits best possible accuracy is another matter. Col. Harrison based his conclusions about bullet lube on extensive and repeatable group testing and settled on the NRA formula of 50/50 pure yellow beeswax and Alox 2138F.

Since Col. Harrison's testing in the 50's and 60's numerous other ingredients and recipes have been tested and many recipes are highly successful. Lubes such as LBT Blue, Felix Lube, LARS and many others come to mind suggesting that while Col. Harrison's testing and conclusions are certainly valid it isn't the final word, the possibilities of even better lubes are endless.

Bull Shop Speed Green

By *weight* 3 parts yellow bees wax (the raw unrefined wax is best because it contains the natural glue's, if it doesn't smell like honey its not right) to 1 part Bull Plate. That's it simple huh?

A couple of cautions, use a double boiler so you don't scorch the wax, over heating the wax to the point of scorching degrades the quality of the wax. Don't use paraffin, it lowers the flash point and causes more fouling.

If you want a less sticky/tacky lube add 1/2 ounce carnauba wax per 1 lb Speed Green, pre melt the carnauba before adding.

If you will be casting sticks I have found the basic 3/1 formula does not release easily from my molds. The cure for this is to add 1/2 ounce Alox per 1 lb lube. I use the original Alox from the Alox corp. in Niagara Falls, NY but they no longer exist. I still have a good supply. I have tried the Lee liquid version just to see and it also worked. If you are just melting and pouring into your sizer you wont need to bother with the Alox. Bullplate is also used as a sprue plate lube and is available from http://bullshop.gunloads.com/ If you would prefer to buy your lube rather than making it yourself Speed Green can be purchased pre-made from Bullshop.

Black Powder Lubes

Emmert's Lube *with lanolin:* I've had better luck with my Emmert's *with lanolin* than I have with SPG. Emmert's is, as I understand it an old Schuetzen lube, and it's simple and easy to make - always a plus. From Bill, (Hip's Ax on Castboolits forum)

50% beeswax,
40% white Crisco (like Mama used to make biscuits with)
10% canola cooking oil.

To that I've added about 6-7% anhydrous lanolin. The lanolin is a good high temp, high pressure lube and it's sticky. It helps the lube stick to the bullets, and helps make it better for pan lubing. Sure has seemed to keep the fouling softer than the SPG.

Buck Emmert's black powder Lube Formula: From Bill, (Hip's Ax on Castboolits forum)

1750 grains Beeswax
1368 grains Crisco Shortening (White)
328 grains Crisco or Wesson Vegetable Oil

This recipe makes 1/2 pound lubricant. If you tray lube as I do, you'll probably want to double the recipe.

Lubes From The Past

From "NRA Cast Bullets" by Col. E.H. Harrison U.S.A (ret.)

U.S. Army, 1855	1 Beeswax 3 Tallow
U.S. Army, 1861	8 Beeswax 1 Tallow
U.S. Army, 1873	8 Bayberry wax 1 graphite
U.S. Army, 1880	Japan wax
Sharps Rifle Co., 1878	1 Beeswax 2 Sperm Whale oil
Massachusetts Arms Co., (Maynard Rifle) 1890	1 Beeswax 3 Tallow
Marlin Firearms Co. 1891	1 Beeswax 4 Tallow
Smith & Wesson 1891	Tallow
Car door latch stick lube	1931 patent, 5 paraffin 3 petroleum jelly 2 oil
Large police dept. 1962	1 Beeswax 1 paraffin 1 Cosmoline
H.M. Pope about 1900	3 mutton tallow 2 Bay wax 1 Beeswax 1 steam cylinder oil .2 of 1 Acheson graphite (can omit bay wax)

Given the dates (except the police lube & door latch lube) these are of course all black powder lubes.

A note on Flux

Flux is a scientific term describing the rate of flow of something through a surface, it has several more specialized uses in English: Flux (metallurgy) is a material that aids in *both* *smelting and soldering* by assisting the flow of the molten metal. In metallurgy, a flux is a chemical cleaning agent which facilitates soldering, brazing, and welding by removing oxidation from the metals to be joined. Common fluxes are: ammonium chloride or rosin for soldering tin; hydrochloric acid and zinc chloride for soldering galvanized iron (and other zinc surfaces); and borax for brazing or braze-welding ferrous metals. Different fluxes, mostly based on sodium chloride, potassium chloride, and a fluoride such as sodium fluoride, are used in foundries for removing impurities from molten nonferrous metals such as aluminum, or for adding desirable trace elements such as titanium.

In high-temperature metal joining processes (welding, brazing and *soldering*), the primary purpose of flux is to prevent oxidation of the base and filler materials. Tin-lead solder attaches very well to copper, but poorly to the various oxides of copper, which form quickly at soldering temperatures. Flux is a substance which is nearly inert at room temperature, but which becomes strongly *reducing* at elevated temperatures, preventing the formation of metal oxides. Additionally, flux allows solder to flow easily on the working piece rather than forming beads as it would otherwise. Flux comes from Latin and means *flow*.

A related use of the term flux is to designate the material *added* to the contents of a *smelting furnace* for the purpose of purging the metal of impurities and oxides and of rendering the slag more liquid. The slag is a liquid mixture of ash, flux, oxides and other impurities. Keep in mind when fluxing your alloy that *reduction is the opposite of oxidation*, a good flux will *reduce* alloy components such as tin back into the melt while oxidized impurities such as dirt, aluminum, zinc or other impurities will be skimmed off the surface with the flux.

A good bullet lube will *act* the *opposite* of flux and *prevent* rather than aiding lead "*soldering*" to the bore. "Flux in solder enables the joining of parts or soldering", bullet lube "*prevents*" lead from sticking (soldering) to the bore. When soldering, rosin is commonly used as flux to remove oxidation of the metals when heated and allow the joining of the parts (the flow of liquid solder) yet both tallow and olive oil (and many others) can successfully be substituted for rosin when soldering and both of these are successfully used in bullet lubes.

So how can the same material be both flux and bullet lube anti-flux? I suspect that temperature is the key, in soldering the solder, flux and material to be joined are all heated above the melting temp of solder (365+ degrees) and the melted flux removes oxidation from the metal surfaces allowing the solder to flow. Your bullet *alloy* melting temp is far above this and even though some of the lube may melt, the bullet does not.

For further reading on alloy fluxing see The "Simple" Act of Fluxing By: Glen E. Fryxell and at the top of this article, "Lubricating Cast Bullets" By: Glen E. Fryxell

For a more detailed description of what you need your flux to accomplish and how it does (or doesn't work) see the book: From Ingot to Target: A Cast Bullet Guide for Handgunners Chapter 4, Fluxing.