surface lubricants

Most rubber products have a good-to-outstanding surface coefficient of friction (CoF). While this drag or resistance-to-sliding is an important feature of products like tires, shoe soles, and golf grips, certain products need a low coefficient of friction (CoF) to enhance the movement of another product (wires, for example) through the rubber part. Ways to reduce slippage on the rubber surface include surface lubricants, fillers, and certain fillers like PTFE or graphite. Certain fillers like PTFE or graphite will provide some surface lubricity in abrasive environments. Fillers used at higher levels than most surface lubricants due to its saturated (no double bonds in the hydrocarbon chain). This double bond alters certain properties, which provide “slip properties.” Slip properties are those needed when two surfaces move at right angle separation of two surfaces (a vertical force rather than the horizontal force of a slip agent).

Proaid LCF is Akrochem’s primary surface lubricant recommendation. Proaid LCF state-of-cure barely declines – no more than a normal dilution effect. Proaid LCF Summary:

- Outstanding reduction in surface coefficient of friction in all tested elastomers.
- Melt point is just 50\(°\)C.
- Used extensively in plastics like PE, PP, and PVC for slip and antiblock properties.
- Friability is very slow to increase in most compounds. The typical process aid loading of 2 phr will be very slow to bloom, if at all. Some stocks may require more than 2 phr if the formula is highly polymer-related as well as loading-related.

Proaid AC-18-E:

- 18-E will develop a less-offensive looking bloom than LCF. The surface is not pristine but the bloom is less noticeable than Proaid LCF. The bloom can be removed from the surface or it can be minimized. Some stocks may find this cosmetically unacceptable. The amides tend to have a less obvious bloom.
- "E" stands for erucamide, a 22-carbon hydrocarbon chain with an amine group on the end. The amine group promotes a slow and gentle bloom compared to other surface lubricants. These are just a few specific applications that found the surface lubricants to ease part assembly, improve movement of parts, and improve surface resistance under Stress, sliding by abrasion, and chemical attack.

Proaid AC-18-O (O) oleamides

\[
\text{CH}_3 (\text{CH}_2)_{16} \text{C} = \text{O}
\]

- Used extensively in rubbers like EPDM, EP, and FKM for slip and antiblock properties.
- Friability is very slow to increase in most compounds. The typical process aid loading of 2 phr will be very slow to bloom, if at all. Some stocks may require more than 2 phr if the formula is highly polymer-related as well as loading-related.

Proaid AC-18-S (S) stearamide

\[
\text{CH}_3 (\text{CH}_2)_{16} \text{C} = \text{O}
\]

- Used extensively in rubbers like EPDM, EP, and FKM for slip and antiblock properties.
- Friability is very slow to increase in most compounds. The typical process aid loading of 2 phr will be very slow to bloom, if at all. Some stocks may require more than 2 phr if the formula is highly polymer-related as well as loading-related.

Proaid LCF EPDM

EPDM Compound with 1, 2, 5, and 10 phr Proaid LCF or erucamide

<table>
<thead>
<tr>
<th>Time (Min)</th>
<th>Proaid LCF</th>
<th>Proaid AC-18-E</th>
<th>Proaid AC-18-O</th>
<th>Proaid AC-18-S</th>
</tr>
</thead>
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<tr>
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</tbody>
</table>

Things to consider when choosing a surface lubricant include: polymer from which the material must bloom; core effects core appearance; PSA data at a point (typical rise (i.e. bloom) core rises a half to two to three times and falls off; optimizing the lubricant will one affect performance test (a), some solid blues that have better starting power, and finally cost. Thickness of the blooming, lubricating film is directly related to the loading. The speed at which a lubricant blooms is a high-polymer viscosity along with loading related.

Despite the claims of a slip agent, Proaid LCF is not a slip agent. Rather, Proaid LCF is a surface lubricant. It will bloom from virtually all polymers (one customer has found it useful in EPDM). These exude an exceedingly oily film; the severe incompatibility of process oil in polychloroprene or nitrile, or silicone fluid in almost anything except silicone – much cheaper than liquid phenyl silicone that was normally used). Proaid LCF can be surface lubricant. It will bloom from virtually all polymers (one customer has found it useful in EPDM). These exude an exceedingly oily film; the severe incompatibility of process oil in polychloroprene or nitrile, or silicone fluid in almost anything except silicone – much cheaper than liquid phenyl silicone that was normally used). Proaid LCF can be

...
surface lubricants

Most rubber products have a good-to-outstanding surface coefficient of friction (CoF) While this drag or resistance-to-sliding is no cause for alarm, certain applications require lower CoF's. In these applications, it is desirable to reduce the surface of the part so that it can slide easily against other surfaces. A number of factors can contribute to a high CoF: abrasion, poor filler distribution or voids, chemical reactions like blooming, and surface contamination or additives. If the rubber is to be designed to slip, the surface must have a slippery or low CoF surface. This can be accomplished by using surface lubricants or coupling agents that are blended into the compound at the mill or by applying a thin, transparent film to the part surface after it is molded. Surface lubricants are added to various rubber compounds to obtain a low CoF or to control sticking. They may be used internally (as fillers or as lubricants) or externally (as primers or sizers). While the use of surface lubricants is well established in the rubber industry, there are many misconceptions about their use and performance. Some common questions regarding surface lubricants include:

- What is the purpose of a surface lubricant?
- What are the requirements for selecting a surface lubricant?
- How do surface lubricants affect the properties of the final product?
- What are the potential side effects of using surface lubricants?

This article will provide a comprehensive overview of surface lubricants, their applications, and how they affect rubber products. It will cover the types of surface lubricants available, how they work, and the factors that influence their effectiveness. By the end of this article, readers will have a better understanding of surface lubricants and their role in improving rubber product performance.

SURFACE LUBRICANTS: continued

Here are a few examples of actual applications where a surface lubricant has been used:

- A mold known for sticking could be a source of poor part quality and high scrap rates. To solve this problem, a surface lubricant was added to the compound. This reduced sticking significantly, resulting in improved product quality and lower scrap rates.
- A rubber component that needs to slide easily against a metal surface is a common application for surface lubricants. By incorporating a surface lubricant into the compound, the component can slide more easily, reducing friction and wear.
- A rubber component that needs to have a low CoF for testing or evaluation purposes can benefit from the use of surface lubricants. These lubricants can be applied to the surface of the component to create a low CoF condition.

In these and similar applications, surface lubricants enable rubber components to slide easily, reducing friction and wear, and improving product quality and performance.

Material Available from Akrochem Chemistry

**Proaid LCF**

- Alkyl amide
- CoF reducing (low CoF)
- Low surface friction

**Proaid AC-18-E (E)**

- Stearamide
- CoF reducing
- Melt point 180 °F

**Proaid AC-18-S (S)**

- Stearamide
- CoF reducing
- Melt point 160 °F

**PROAID LCF**

- This product has been found to be the most effective of all rubber lubricants available.
- It contains a high concentration of lubricant material.
- This makes it extremely effective at reducing CoF.

**PROAID AC-18-E**

- This lubricant is the second best blooming lubricant available.
- It is slightly better than Proaid LCF in terms of blooming, but it is less effective in blocking.

**PROAID AC-18-S**

- This lubricant is the third best blooming lubricant available.
- It is the best blocker available, but it is not as good as Proaid LCF in terms of blooming.

**Note**

The state of a state-of-the-art lubricant will dictate the most effective lubricant to use. Note that some state-of-the-art lubricants may require more than one type of lubricant to get the desired effect.
surface lubricants

**Most rubber products have a good-to-outstanding surface coefficient of friction (CoF). While this drag or resistance-to-sliding is an important feature of products like tires, shoes soles, and golf grips, certain products need a low CoF (less than 0.25) to prevent the parts from dragging, especially during installation or assembly, increased abrasion and scratch resistance, and reduced sticking of the parts to other surfaces.

There are many ways to create a low coefficient of friction (CoF) on a rubber sample. Most compounds have (naturally or by their chemistry) a low CoF on their rubber surface by adding an incompatible material to the surface. A few examples would be liquid chloroprene (PILG), epoxidized polyphenylene oxide (EPPO), silicone fluid (Silicones), or any of the oils and greases that were commonly used in the past. These create an essentially oily film, the surface incompleteness of which causes some wear and abrasion problems. Used improperly, these compounds are usually adversely affected.

Certain fillers like PTFE or graphite will provide some surface lubricity in abrasive applications but there are drawbacks: only that material at the surface at the time of molding has any immediate effect and for large parts, the powdered or granular material must be added to the compounded rubber to provide a good surface condition. A few materials show a problem of migration and/or excessive interaction. In general, fillers may be used in severe abrasive applications where a smooth surface of the rubber is desired. The highly filled rubber surface is exposed to these types of internal lubricants, there is minimal slipage on the rubber. The effectiveness of the compound will also depend on the change in the state of cure (see rheographs to the right). The actual amount of the product present (see, for example) the thickness of the bloomed, if at all. Some stocks may require more than 5 phr if the formula is highly polymer-related as well as loading-related. Some things to consider when choosing a surface lubricant include: polymer from which the material is made; cure effects; cosmetic appearance; FDA status. PTFE and graphite may be useful in severe abrasion applications where a smooth surface of the rubber is desired. However, with the molded surface is abraded to expose these filler-type internal lubricants, there is minimal slipage on the rubber. This prevents using these fillers as assembly aids or impregnation aids prior to and during molding. After molding, the lubricant’s polar end migrates to the cured rubber surface so well, the bloomed film is completely blocked from the surface by the other materials in the molded part. The unsaturated nature of erucamides means some of the sulfur cure will be siphoned-off resulting in a lower state of cure than would be expected from the formula’s cure time. Thus, some compound stocks may require more than 5 phr if the formula is highly polymer-related as well as loading-related. Some things to consider when choosing a surface lubricant include: polymer from which the material is made; cure effects; cosmetic appearance; FDA status. PTFE and graphite may be useful in severe abrasion applications where a smooth surface of the rubber is desired.

**Surface Modifications**

**ERUCAMIDE EPDM**

- **Proaid LCF** summary:
  - LCF promotes a remarkably effective slippage with few drawbacks other than a bloomed appearance that may not be cosmetically acceptable in some parts. LCF has not been seen to have any immediate effect and for large parts, the powdered or granular material must be added to the compounded rubber to provide a good surface condition.
  - Proaid LCF can be used at higher levels than most other lubricants due to its solubility (too soluble in the matrix, cured rubber)
  - Enamels and enamels have double bonds in them that dilute the state of cure (see rheographs to the right).

**PROAID LCF EPDM**

- **Proaid LCF** has been found to be the most effective all-around surface lubricant in EPDM. Due to its effectiveness, Proaid LCF is used extensively in EPDM compounds. Proaid LCF is an excellent mill and mold release (for outstanding ease of milling and high mold release)

**Materials Available from Akrochem Chemistry**

- **Proaid AC-18-O** (O) oleamide
  - 
- **Proaid AC-18-S** (S) stearamide
  - 
- **Proaid AC-18-E** (E) erucamide
  - 

Proaid LCF Compound with 1, 2, 5, and 10 phr Proaid LCF or erucamide

**Notes**

- Notice how the state of cure slowly declines as the bloom increases with each increment of LCF (see rheograph to the right).

**EPDM Compound with 1, 2, 5, and 10 phr Proaid LCF or erucamide**

**PROAID LCF Summary:**

- **OUTSTANDING reduction in surface coefficients of friction in all test specimens.
- Minimal effect on cure.
- For good lubrication and quick bloom, 4 to 5 phr has been shown to work well.
- Professional product and loading in most compounds. The typical process aid loading of 2 phr will be very slow to give the desired bloom, 4 to 5 phr is a formula that is limited to the test results given above (up to 4% higher still gives minimum state of cure). The recommended loading of 2-3 phr allows good bloom and conditioning.
- Cost effectiveness is excellent (cost will vary with amounts of LCF used).
surface lubricants

Most rubber products have a good-to-outstanding surface coefficient of friction (CoF). While this drag or resistance-to-slip can be reduced by using oils or waxes, there are three ways to create a low coefficient of friction (CoF) on a rubber sample. Most compounds have (usually react to their chemicals) intentionally created a low CoF on their rubber surface by adding an incompatible material to the surface. A few examples would be liquid chlorinated paraffins, which are used to reduce the surface tension of the rubber, and grommets in an auto firewall had wires passed through them. Here are a few examples of actual applications where a surface lubricant has been used:

- A hospital IV pole with rubber stoppers had to slide up and down but still maintain a reasonable friction level. Addition of a CoF reducer allowed elimination of this step.
- Grommets in an auto firewall had wires passed through them. Dragging the long wires through the firewall caused an annoyance every time the vehicle was started. A surface lubricant reduced the coefficient of friction, allowing the wires to slide through the grommet without any resistance.

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SURFACE LUBRICANTS: continued

Amide group (polar region)

The趋于极性的酰胺基团在橡胶或塑料部件的表面被“拖动”来测量摩擦系数（CoF）。一个方法是ASTM D-1894，其中规定了一个“sled”被拖过表面的距离。

初步研究的摩擦系数降低结果:

- Proaid AC-18-O:
- Proaid AC-18-E:
- Proaid AC-18-S:
- Proaid LCF:

- bloom减少更为明显。

- 热稳定性在高温处理的聚烯烃中找到应用。

- 非极性相

- 注意使用适量的添加剂，因为过量的添加剂会导致表面污染。

- 由于少量的添加剂可能在极性相中溶化，所以对添加剂的使用需要小心。

- 虽然所有表面润滑剂均在规定中列出，但多数为多功能添加剂。因此，要充分考虑添加剂的特性，才能达到最佳效果。

- 另一位客户刚刚有足够润滑剂得到满意的联锁层。随着时间的推移，他看到晶体重新结晶在部件的凹陷中。

- 低分子量的润滑剂可以改善表面润滑剂的性能。

- 润滑剂在表面将不会改善橡胶的性能，特别是在与高度磨料的材料接触时。

- 物理性质的变化将使表面润滑剂有助于橡胶的性能，因为小的添加剂可以改变橡胶的表面性质。

- 任何使用技术信息的人员均被视为阅读并接受“技术信息”中的内容。美国阿科赛姆公司不对因使用任何产品、方法或过程而引起的任何损失、损害或任何其他损失负责。
SURFACE LUBRICANTS: continued

Amide group (polar region) offers excellent slip (below 0.30 for plastics). Here are a few typical results:

- Minimal plastic content will have CoF's above 1.30. A rubber CoF below 0.40 indicates
  that the additive is working as a lubricant.
- Most rubber stocks have a CoF above 0.70 without lubricant. Soft rubber with a balanced
  surface interface will have a CoF lower than 0.40. When a rubber is being covered
  with protective coatings, such as in unplasticized Hypalon where calendar sheets
  are rolled up on themselves without a separating sheet, a high CoF will allow the
  sheets to separate from one another when a calendar roll is ready to be used.

Pelleted forms of amides are used extensively in direct food contact applications like plastic food wrap.

Further Information on Slip Agents:

- FDA Status: Applying FDA regulations to rubber chemicals can be a slippery business at times.
  Surface lubricants meet the provisions of many regulations. Based on paragraph c (3), this
  section states: “Substances...the amides are used extensively in direct food contact applications...”

Lab Study of Reduction in Coefficient of Friction (CoF): This method is used to measure coefficient of friction (CoF) of ATD-100 where a weighed sled is dragged across the surface of a rubber or plastic part. Surface lubricants can be applied in a liquid form, typically as an 18-carbon saturated (no double bond) fatty chain with a polar amide group on the end. Stearamides have found use in unplasticized Hypalon where calendar sheets are rolled up on themselves without a separating sheet. The stearamide is the most efficient anti-block lubricant among the amides. This allows sheets to separate from one another when a calendar roll is ready to be used.

- Another customer had just enough lubricant to get a satisfactory bloom. Over time he saw
  occasional rotation in the blisters. Sometimes it took only two days, sometimes it took two
  weeks to develop a good bloom. This difference had occurred in one case within a single
  box of lubricant, which made it unlikely that the lubricant was the variable. In the other
  case, the customer's other raw materials apparently mixed such that it caused the
  blooming process to stop. Loosely formulated oleamide has less heat stability than
  its saturated counterparts, so less can be used with the same result. A double bond does
  cause the geometry of the lubricant to cover a greater area.

- The blooming nature of these surface lubricants will help bring chemical antiozonants like
  UV resistant inhibitors to the surface where they can serve any purpose. A surface lubricant may help
  bring other materials to the surface as well. One example is UV inhibitors that have
  impact abrasion.

- Abrasion resistant applications may be aided by the presence of a surface lubricant. While
  sliding abrasives will have a reduced effect on the rubber due to the lower coefficient of
  friction. An O-ring that fails due to rubbing causing enough wear to create a gap can extend
  its useful life by adding a surface lubricant. Gaskets and seals are prevented from “galling”
  or chaffing on metal surfaces during service by self-lubrication. However, a lubricant on the
  surface will not improve rubber's performance on severe materials or severe abrasion.

- The blooming nature of these surface lubricants will help bring chemical antiozonants like
  UV resistant inhibitors to the surface where they can serve any purpose. A surface lubricant may help
  bring other materials to the surface as well. One example is UV inhibitors that have
  impact abrasion.

- The amount used to develop a consistent lubricating bloom will differ with every compound.
  The blooming rate to change. By increasing the loading of lubricating material to a level that
  would perform properly even when the other raw materials varied, the customer solved
  the inconsistent bloom issue.

- Another customer found that just enough lubricant to just enough lubricating bloom would
  provide wear resistance to the rubber below and after cure. In one such case, water spotting from
  moisture inclusions was reduced (a higher molecular weight amide may be best for this — ask about Advawax 280). In cured rubber, the bloomed film forms a thin lubricant film and
  prevents ozone from reaching the rubber.

- FDA Listings

- Included with its product literature and upon the request of its customers, Akrochem provides product specifications and...
Amide group (polar region) offers excellent slip (below 0.30 for plastics). Here are a few typical results:

- Minimal plastic content will have CoF's above 1.30. A rubber CoF below 0.40 indicates that since the amides, Proaid AC-18-E, O, and S, have extensive FDA history and are permitted to be carried out [such as extraction testing per parts (e) and (f)]. It would be our suggestion that by regulation in parts 170 through 189 of this chapter may be safely used in rubber. Remember that any other 177.2600 relevant testing must be considered for any compound.

- The blooming nature of these surface lubricants will help bring chemical antiozonants like p-phenylenediamines to the surface similar to petroleum waxes. The surfactant-like nature of these materials can help bring other materials to the surface as well. One example is UV inhibitors that have the inconsistent bloom issue.

- Another customer had just enough lubricant to get a satisfactory bloom. Over time he saw occasional rotation in the blooms. Sometimes it took only two days, sometimes it took two weeks to develop in a good bloom. This difference occurred in one case within a single batch of lubricant, which made it unlikely that the lubricant was the variable. In the end, the customer's other raw materials apparently reacted in such a manner that they caused the bloom behavior. We do not find that a lubricant is a loss factor if it has a high level that would work properly even when other raw materials varied, the customer solved the inconsistent bloom issue.

- Abrasions resistance may be aided by the presence of a surface lubricant. Abrasion resistance would have a reduced effect on the rubber due to the lower coefficient of friction. An O-ring that fails due to rubbing causing enough wear to create a gap can extend or chaffing on metal surfaces during service by self-lubrication. However, a lubricant on the surface will not improve its performance with severe abrasions.

- The blooming nature of these surface lubricants will help bring chemical antiozonants like p-phenylenediamines to the surface similar to petroleum waxes. The surfactant-like nature of these materials can help bring other materials to the surface as well. One example is UV inhibitors that have the inconsistent bloom issue.

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Surface Lubricants: continued

rubber surfaces

Amide group (polar region)

minimal plastic content will have CoF's above 1.30. A rubber CoF below 0.40 indicates

Most rubber stocks have a CoF above 0.70 without lubricant. Soft rubber with

One method to measure coefficient of friction (CoF) is ASTM D-1894 where a

Lab Study of Reduction in Coefficient of Friction:

Proaid AC-18-O:

Proaid AC-18-S:

pelleted form for ease of handling. Like the erucamide (E), the oleamide's (O)

(18-O) is a high quality oleamide (based on amide content and low acid value) of excellent color. It comes in a

in most of the same applications where erucamides are used. Oleamides will bloom faster than erucamides in polyolefin films. The oleamide in sheet or strip has slightly less bloom than the erucamide but also is inherently less costly. The 18-O is a high quality oleamide (based on amide content and low acid value) of excellent color. It comes in a

heat stability finds use in high-temperature-processed polyolefins.

if printing or sealing must be done to a product shortly after production. Its

than its saturated counterparts, so less can be used with the same result.

double bond does cause the geometry of the lubricant to cover a greater area

177.1210, 178.3120, 178.3910, 179.45, 181.28

177.1350, 178.3120, 178.3910, 179.45, 181.28

177.1210, 177.1350, 177.1400, 178.3860

EPDM without lubricant (control) 1.183

CR with 10 phr Proaid AC-18-E 0.369

CR with 5 phr Proaid LCF 0.322

CR without lubricant (control) 1.382

NBR with 10 phr Proaid AC-18-E 0.367

Further Information on Slip Agents:

• Rutabite: Rutabite is a blend of TPV, CR, and NBR formulations that have good lubricty characteristics and can be applied by spraying at any time. All Akrochem’s products have FDA status under current regulations (see below). In fact, the amides are used extensively in direct food contact applications like plastic food wrap. However, none of the surface lubricants appear in the regulations as additives compounds considered their final test. 177.2600, Rubber Articles Intended for Repeated Use. To allow use

The blooming nature of these surface lubricants will help bring chemical antioxidants like

Some trial-and-error is needed to optimize the lubricant level. Start

absorb active materials and oils that solubilize chemicals, will require more lubricant material

rubber, the bloomed film forms a barrier to moisture.

– One customer used a lubricant to excess. Instead of a creamy haze of a bloom, copious

– Another customer had put enough lubricant to get a satisfactory bloom. Over time he saw

Agriculture and Forestry. As a result, it may be used in articles of commerce. A surface lubricant is brought to the surface can it serve any purpose. A surface lubricant may help

or chaffing on metal surfaces during service by self-lubrication. However, a lubricant on the

The blooming nature of these surface lubricants will help bring chemical antioxidants like petrochemicals to the surface similar to polyelefin compounds. The surfactant-like molecules can help bring other materials to the surface as well. One example is NBR which has been used with no problems.

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