metallic stearates (metal salts/soaps)

Metallic stearates have been utilized in the rubber industry a long time. The primary functions of metallic stearates are their ability to prevent rubber from sticking to the mold as well as to itself. The compounder has found numerous ways to take advantage of the physical and chemical properties of metal stearates. This solution paper will discuss the metal stearate chemical properties, physical properties and the application in rubber.

introduction

Fatty acid metal salts or soaps play an important role as a process aid. These stearates are viewed as salts or soaps in general terms. For the purpose of this paper we will refer to them as salts. These salts are produced from a reaction with stearic acid (fatty acid) and a metal oxide. The make up is typically of a hydrogen chain and a carboxylic group. They are formed by substituting the carboxylic hydrogen by a metal to get the salt. Metallic salts are possible since the combinations of acid and metal are almost limitless. However, for practical purposes, the commercial metallic salts are limited to those derived from stearic, palmitic, lauric, oleic, and tall oil acids. Stearic acids are straight-chained saturated, monobasic acids found in vegetable or animal fats. The two metallic stearates used extensively in the rubber industry are calcium and zinc. The zinc salts have the largest market. The commercial grades of metallic stearates are from stearic acid having about 30-60% palmitic acid. The main criterion in selecting one of the stearates is overall cost.

chemical structure

The chemical structure of the metallic stearates consists of a very stable hydrocarbon. The long-chain hydrocarbon structure is insoluble in water and thus provides the hydrophobic nature of metallic stearates. Most stearates are thought of as a salt. This salt of a stearic acid is formed by replacing the carboxylic hydrogen by a metal to yield a salt. (See Figure 1)

Figure 1. Carboxylic hydrogen replaced by a metal

C (16-18)-H(n)-C-O-(metal)
ll
O-or –(R)

physical properties

The physical properties of metallic salts that make them useful for a variety of purposes are: lubricity, water repellency, low melt point, and hydrogen solubility. The types of fatty acids derived from the above sources have various physical characteristics such as carbon chain length and unsaturated bonds that help define the usefulness in different polymer systems (see Table I). The physical properties are all fairly similar between the two stearates. The most significant property differences as they relate to the rubber release agent are the melt point (see Table II) and solubility (see Table III). Chain length, saturation and linearity affect the melt point of the final product. The melt point plays a huge role in the decision of which kind of product to use on the surface of the uncured rubber. For example, the zinc stearate will melt during molding and be absorbed into the compound without leaving discoloration or defects on the surface of the final molded rubber part.

TABLE I

FATTY ACIDS	LENGTH (LINEAR)	MELTPOINT,°C
Lauric	$C_{12}H_{24}O_2$ (saturated)	44
Myristic	$C_{14}H_{28}O_2$ (saturated)	54
Palmitic	$C_{16}H_{32}O_2$ (saturated)	63
Stearic	$C_{18}H_{36}O_2$ (saturated)	69

TABLE II

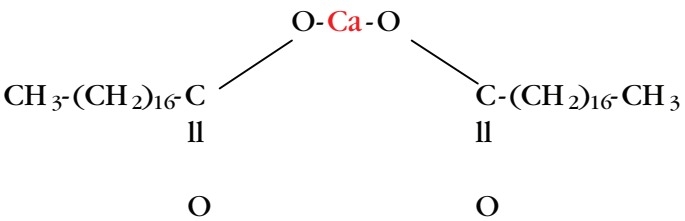
PRODUCT	MELT POINT, °C
AKROCHEM® Zinc Stearate	121
AKROCHEM® P-4000 Calcium Stearate	148

TABLE III

STEARATES	SOLUBILITY PARAMETERS [(MPa) ½]
AKROCHEM® Zinc Stearate	18
AKROCHEM® P-4000 Calcium Stearate	18
Various Polymers	16-20

P-4000 calcium stearate

P-4000 calcium stearate is an effective internal lubricant, mold release agent, and acid scavenger in many applications; and can also be used in the processing of some polyolefins. P-4000 acts as an anti-sticking agent for rubber slab where a dry powder is preferred. It is used in concrete and mortar admixtures to impart water repellency and to improve flow and release properties of the dry mix.



Typical properties are shown below.

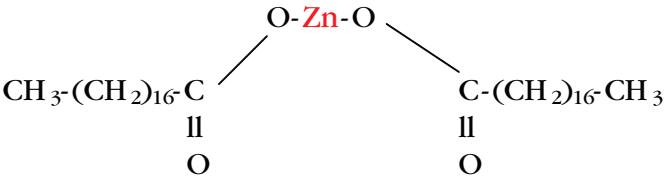
Typical Properties

Appearance	white to off-white powder
Total Ash %	9.0%
Free Fatty Acid	1.0%
Moisture	2.0%
Melting Point	148°C
Fineness, through 325 mesh	99.8%

P-4000 conforms to all ANSI/NSF Standard 14 component requirements and to PPI TR-3 Part O for use in pressure pipe applications. P-4000 meets various FDA Standards set forth in 21 CFR. Calcium Stearate is not a SARA 313 Reportable Substance.

zinc stearate powder

Zinc Stearate powder is an effective internal lubricant, mold release agent in plastic processing and rubber applications, and to some degree can also provide acid scavenging properties. Zinc stearate is the metallic carboxylate of choice in most polyolefin processing applications due to its functionality and low moisture content. Zinc Stearate complies with FDA Standard 21 CFR sections 177.2600 Rubber Articles Intended for Repeated Use and 178.2010 Antioxidants and/or Stabilizers for Polymers.



Typical properties are shown below.

Typical Properties

Appearance	white powder
Total Ash (as ZnO)	13.5%
Free Fatty Acid	0.5%
Moisture	0.5%
Melting Point	121°C
Fineness, through 325 mesh	99.0%

general applications

Metallic stearates provide some unique properties that make them ideal rubber release agents. The combination of lubricity, hydrophicity and melt point allow these materials to be used in several applications. The metallic stearates can be used because of their higher solubility in higher dosages without too much danger of blooming. Metallic stearates are utilized for several reasons. Aside from being an effective lubricant, they facilitate and improve the preparation of the compound for further processing. They also lower the mixing and processing temperatures and help to save energy. Metal stearates improve dispersion of the components of the rubber compounds. Zinc stearate is frequently used as dusting medium because of its ability not to affect the tackiness of rubber compounds. P-4000 Calcium Stearate is effective during processing at high shear rates in various elastomers. In polychloroprene zinc stearate accelerates the crosslinking reactions during processing. Therefore, zinc stearate would affect the processibility behavior negatively, especially at high shear rates, which can cause scorching in the mixer. In general purpose elastomers very good improvements of the processibility behavior can be obtained with zinc stearate.

Metallic stearates are used as dry lubricants in a variety of applications. In the plastics industry, they are added to resin (PVC type) granules to provide lubrication and mold release in injection molding applications. P-4000 Calcium Stearate is used as a lubricant in the preparation of resin-coated sand for metal casting by the shell molding technique.

Zinc stearate is used in the rubber industry as a mold release and between sheets of raw rubber to prevent sticking. It does not contaminate the stock since zinc stearate is frequently used in the recipe to act as a softening agent and dispersing agent for pigments and fillers.

The water-repellent properties of metallic salts find application in such diverse fields as cements, cosmetics, powders, and masonry treatments. In case of masonry treatments, they are usually applied from a solvent solution.

Each rubber application has different requirements and may require various release agents depending on the process or compound needs. The most common reasons why metallic stearates are used as release agents are:

- Uncured rubber needs heat removed quickly, to prevent scorching, thus, the rubber needs to be water-cooled before stacking or storage.
- Uncured rubber will be molded with minimal or no post milling or mixing, i.e. compression and transfer molding.

Metallic stearates can be applied to rubber several ways and in different forms. In the powdered neat states, stearates are applied or dusted onto the surface of the rubber passing the rubber through a trough or box containing the stearate or apply by hand. This process is somewhat crude and dusty, but is effective in applying the lubricant to the surface of the uncured rubber.

specific applications

Photographic toner application uses zinc stearate as a release agent at approximately 1.5 to 3.0 parts. Zinc stearate does not affect the electrical properties of the toner.

In a coextrusion plastic application zinc stearate is used as a slip agent to improve the ease of passage through the extrusion.

Metal stearates are used in polymers like EPDM seals (1.0 phr), EVA low melt film (0.8 phr), Polyamide (.5 phr), Polycarbonate sheets (1.0 phr), and Polyester sheet molding (.8 phr).

Below are additional applications where metallic stearates are used:

Calendaring
Crystalline Film
Adhesives and Sealants
Ceramic
Coated Fabrics
Medical Devices
Roofing Materials

summary

Metallic stearates can be used in several operations in a rubber company to provide release. The physical properties of lubricity, hydrophobicity, compatibility and melt point are all important in providing the necessary performance required of a rubber release agent. The versatility of how they can be applied and formulated is the reason why rubber manufacturers still choose metallic stearates.

AKROCHEM CORPORATION