Stepan Company has been a leading producer of specialty and intermediate chemicals for over 70 years. Corporate headquarters are located in Northfield, IL, and sales offices are located around the world. With fifteen manufacturing sites worldwide and over 1400 employees, our company is becoming a key player in the global marketplace. Many different types of surfactants are used in metalworking fluids, including sulfonates, alkoxylates, phosphate esters, carboxylic acid esters, and amides. Manufacturing these and developing new products of the same type is a core Stepan technology. Our experience, strong R&D capability and market knowledge will benefit our metalworking fluid formulators.

Background
Surfactants used in the metalworking industry are mature and well understood. In response to this issue, Stepan Company is introducing a series of hydrolytically stable esters for use in metalworking and hydraulic fluid applications based upon our polyester polyol technology. STEPAN® MWA-500HS series esters possess superior hydrolytic stability as compared to Isopropyl Oleate (IPO) considered the hydrolytic stable standard. These products in addition to being excellent lubricants can deliver corrosion inhibition to non-ferrous metals.

Other technologies that Stepan is currently investigating include alternate alkanolamides and new approaches using phosphate esters. Stepan is developing alkanolamides based on amines other than DEA, DIPA and MEA. Stepan has introduced two phosphate ester based upon proprietary technology, as ferrous metal corrosion inhibitors. These products are non-staining to aluminum and provide extreme pressure (EP) and anti-wear properties to the fluid.

Structure And Performance
Our family of Stepan hydrolytically stable esters are principally ortho phthalic acid anhydride (o-PA) based oligomers. Using the flexibility of this o-PA backbone allows Stepan to alter the oligomer enabling us to change the solubility features of these molecules. Stepan is offering oil soluble, water soluble and self-emulsifying products. We tested hydrolytic stability using Gel Permeation Chromatography (GPC). We measured the loss in molecular weight over time in a controlled environment. The o-PA based esters were compared to an adipate ester at two different pH levels: 1) pH=8.5 using 0.5M triethanolamine, and 2) pH=13.7 using 0.5M potassium hydroxide, the samples were aged at 93°C over 20 days. Figure 1 displays the loss of molecular weight peak in all four solutions over the testing period.

The STEPAN MWA-560 HS hydrolytically stable ester was completely stable over the 20 day period whereas the adipate ester broke down almost immediately. Recent experiments have shown that IPO, which is generally regarded as hydrolytically stable, broke down in a matter of days as did the adipate. We attribute the hydrolytic stability to the ortho configuration of the acid groups in the ester. Similar experiments with meta and para phthalic based esters indicated that they were hydrolytically unstable.
Lubrication Properties

The lubrication properties were tested in the 4-Ball Wear (ASTM D4172-B) and Pin & Vee (ASTM D-3233) and all samples were tested at Falex Corporation. Lubrication properties were found to be equivalent to Isopropyl Oleate. (Figure 2)

STEPAN MWA-580 HS and 581 HS are completely soluble in waters as high as 1000ppm, STEPAN MWA-590 HS, 591 HS and 592 HS are self emulsifying in these same waters. Regardless, PEG 400 block is soluble in 1000ppm hard water. The STEPAN MWA-500 HS Series products delivered comparable lubricity properties to IPO.

Corrosion Properties

In addition to excellent lubricity properties, the hydrolytically stable ester chemistry also provides corrosion inhibition to non-ferrous metals. They have shown exceptional performance in both the ASTM D-4627-92 and DIN 51360 part 2 tests.

Besides hydrolytically stable esters, Stepan offers other types of corrosion inhibitors. STEPAN MWA-310, an oil soluble product, and STEPAN MWA-311, a water soluble product are excellent corrosion inhibitors. These two products are proprietary phosphate esters and they can be used in oil based or water based formulations providing exceptional performance, meeting or exceeding that provide by di-basic acids was shown in the ASTM D-4627-92 (Figure 3) and DIN 51360 part 2 (Figure 4) rust tests.

Conclusions

Stepan Company has a full line of Metalworking fluid additives based on it core technologies including o-PA based hydrolytically stable esters, phosphate esters and alkyl sulfonates. The additives should be a useful addition to the more generic materials available in the market today.
General Description And Highlights

• STEPAN® MWA-560HS and 570HS can generally be described as a propoxylated polyester-polyol based on Phthalic Anhydride (PA). The actual structure, protected under a patent disclosure, is the n = 2 oligomer of PA/Diethylene Glycol (DEG) which is then alkoxylated with propylene oxide.

• The two most important attributes: Hydrolytic Stability and Lubricity. Compared to an industry standard (Isopropyl Oleate), the MWA-560HS and 570HS gave superior hydrolytic stability (i.e. will not break down in the presence of water at any given pH level, temperatures below 100˚C) and comparable lubricity results (“4-Ball Wear,” “Pin &Vee,” and “Tapping Torque” tests).

• MWA-560HS and 570HS are oil soluble, but can be emulsified using many types of nonionic surfactants. STEPAN MWA-250 and 251 can easily emulsify both in aqueous solutions.

• STEPAN MWA-310 and 311 are multifunctional anionic additives that were developed to provide corrosion inhibition. STEPAN MWA-310 is an oil soluble product that provides not only corrosion inhibition but can be used as your primary emulsifier instead of a heavy sulfonate. STEPAN MWA-311 is water soluble and will work exceptionally well in semi-synthetics and synthetic systems as the primary corrosion inhibitor. Both are 100% active liquids at room temperature.

Benefits

• Immediate Commercial Availability
• Excellent Hydrolytic Stability
• Exceptional Lubricity
• Excellent Thermal Stability
• Versatile Chemistry
• Ability to Vary HLB
• Bio-stable
• Low Corrosion
• Easily Emulsified
• Low Foaming

Usage And Application

• The majority of our Metalworking Additives product line is used as emulsifiers, lubricants, and corrosion inhibitors. All of these products are utilized as additives (not major components) of metalworking fluids for cutting, stamping, and tooling metals. In general, these fluids provide the necessary anti-wear, lubrication, heat transfer, and extension of equipment lifetime that is required for working with metals.

• STEPAN MWA-560HS can be used as a straight substitute for ester and/or amide-type lubricants in metalworking formulations.

• Typical ester loadings in metalworking formulations range from 1-15%. We recommend starting at the 5% addition level.

• STEPAN MWA-560HS and 570 HS may be suitable in Extreme Pressure (EP) lubricant used in gears, hydraulics, pumps, and rolling mills.