



SynergexTM **multifunctional** amine additives **extend the life** of metalworking fluids.

This range of lower-odor, lower-volatility products from Eastman offers excellent buffering and pH stability.



EASTMAN

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1. Synergex™ product selection guide

Synergex™ neutralizing amine additives from Eastman significantly boost performance while extending the life of your metalworking fluids.

Table 1—Formulating with Synergex

Amine	Fluid type(s)	Equivalent weight	Odor	LD50 (oral/rat) mg/kg
Synergex	O/W emulsion, synthetic	117	Slight	1150
Synergex T	Synthetic	161	None	4250
Synergex T Plus	O/W emulsion, synthetic, straight oil	217	None	2823
Synergex LA	O/W emulsion	173	Light	550

Synergex

This workhorse alkanolamine has been in use for decades. It helps extend fluid life and can easily be incorporated into oil-in-water (O/W) emulsions.

Synergex T

The hydrophilic tertiary amine alternative to Synergex provides longer life in full synthetic fluids along with excellent corrosion inhibition.

Synergex T Plus

Superior extension of fluid life. Easy incorporation into oil-in-water (O/W) emulsions.

Synergex LA

As the newest addition to our Synergex product line, Synergex LA serves as a highly effective hydrophobic alkanolamine for hydrophobic/hydrophilic amine combinations.

Table 2—Formulating with Synergex amines

Amine	NBP	% VOC	HLB	Typical use level (%)	Biosynergy	Oil/water partition	pKa
Synergex	200°C	99	Midrange	4–6	Excellent	Amphiphilic	10
Synergex T	285°C	< 8	Hydrophilic	2–10	Good	Water	9
Synergex T Plus	> 300°C	0	Hydrophobic	2–6	Excellent	Oil	9
Synergex LA	230°C	99	Hydrophobic	4–8	Good	Oil	10

NBP = normal boiling point

% VOC per ASTM-D1868

NK = not known

Typical use level designates the typically optimal amount to use in a concentration, which in turn will be diluted to ≈ 5% in the working fluid.

2. Formulating with Synergex™

Synergex products can extend coolant life and improve the performance of most water-based metalworking fluids.

Synergex multifunctional amine additives from Eastman can be used in combination with other amines or used by themselves in a concentrate, used tank side, or used to make corrosion inhibiting salts and amides. Synergex products can extend coolant life and improve the performance of most water-based metalworking fluids.

Including Synergex in your coolant formulas can offer multiple benefits:

- Extended coolant life
- Improved pH control
- Greater emulsion stability
- Low volatility and low odor
- Good water solubility
- Compatibility with other additives:
 - Biocides
 - Fungicides
 - Metal deactivators
 - Corrosion inhibitors
- Easy salt formation with:
 - Corfree® M1
 - Sebacic acid
 - Neodecanoic and isononanoic acid
 - Caprylic/capric acid
 - Boric acid

Amine carboxylate with Synergex

One of the easiest ways to insert Synergex into synthetic and semisynthetic formulations is to prepare a Synergex dicarboxylate salt rust inhibitor. The following example can easily be prepared by simple blending without the use of an outside source of heat

Table 1		
Amine carboxylate salt	Lb	%
Water	200.00	47.06
Corfree® M1 *	108.00	25.41
Synergex	117.00	27.53
Total	425.00	100.00

* Corfree® is a registered trademark of INVISTA S.a.r.l.

Start with water and blend in the Synergex; then add the Corfree® M1 until most of the granules are dissolved. Mix until clear.

Note of caution: Some heat of solution will be generated during this process.

The formula makes 50 gallons of Synergex salt with the following properties:

Table 2		
Properties	Results	
Color	Amber	
Odor	Bland	
Lb/gal	8.6	
Solids	50%	

- pH = 6.91 @ 1.0/1.0 Synergex/Corfree M1 ratio
- pH = 7.58 @ 1.1/1.0 Synergex/Corfree M1 ratio
- pH = 8.55 @ 1.2/1.0 Synergex/Corfree M1 ratio
- pH = 9.02 @ 1.3/1.0 Synergex/Corfree M1 ratio (odor is shifting from soapy to more amine-like)
- pH = 9.38 @ 1.4/1.0 Synergex/Corfree M1 ratio
- pH = 9.56 @ 1.5/1.0 Synergex/Corfree M1 ratio

If this Synergex salt is used to make up 24% of the synthetic or semisynthetic formulation, the concentration of Synergex in the final concentrate will be 6%, which is ideal for optimizing all the benefits of a synergistic amine. The Synergex salt will be replacing rust inhibitors that typically contain only 5% to 25% water, so adjust your formula accordingly.

Semisynthetic testing

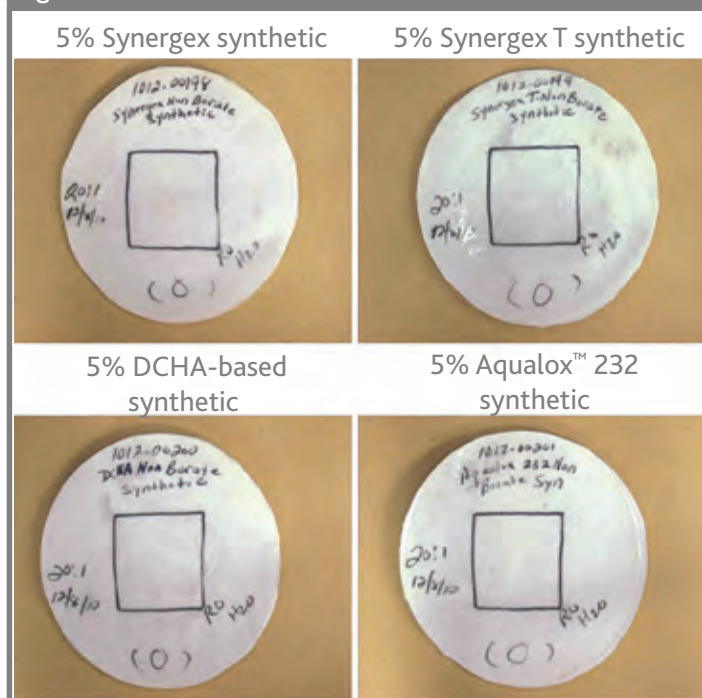
Here is a recommended semisynthetic formula incorporating the Synergex/Corfree® M1 acid salt:

Ingredient	Wt%
1 Water	19.00
2 Synergex	9.00
3 Corfree® M1	8.00
4 Antifoam	0.15
5 Sodium tolyltriazole 50%	0.10
6 EDTA 40%	0.10
7 DIPA oleamide 2/1 molar ratio	20.00
8 Low rosin tall oil fatty acid	8.00
9 Naphthenic oil 100 SUS	22.00
10 High mol wt fatty ester	9.00
11 PEG 600 monotallate	1.00
12 4-mole ethoxylated alcohol	3.00
13 Fungicide	0.65
Total	100.00

The semisynthetic formula with a Synergex salt rust inhibitor was compared to a semisynthetic formula made from DCHA and another semisynthetic formula with a commercial TEA/primary amine-based boramide. All three formulas showed no rust in distilled water at a 20:1 dilution in a typical cast iron chip on filter paper rust test.

The aluminum leaching results were very favorable to Synergex-containing semisynthetics as both the results and the pictures show. Also, in the cobalt leach, the Synergex-containing synthetics did very well. Lastly, the cast iron chip rust testing showed that, at the concentrations necessary for long coolant life (5% [20:1 dilution]), there is no trace of rust.

Figure 1



Aqualox™ is a trademark of the Lubrizol corporation.

Corrosion inhibition in synthetics

We compared the amine-carboxylate with Synergex salt rust inhibitor to a similar rust inhibitor made from DCHA, Synergex T and the commercial rust inhibitor Aqualox™ 232. The rust inhibitors were formulated at 20% with 20% diisopropanolamine and the usual additions of tolyltriazole, fungicide and antifoam. All four formulas showed no rust in distilled water at a 20:1 dilution in a typical cast iron chip test on filter paper. See Figure 1. This is not surprising in that the level of Corfree® M1 is the same for all four.

These synthetic formulas were also tested for aluminum corrosion. The aluminum stain test is run using Al 1100 H14 coupons placed in a jar covered with the sample and allowed to sit for 24 hours. The coupon is weighted before and after the test, and any staining is noted when the coupons are removed. ICP/emission was used to determine the dissolved metal concentration (measured in ppm) of aluminum which leached out of the coupon. All formulas were boric acid free and included Corfree® M1. Synergex T performed the best with 50% less loss of aluminum than DCHA and only 17% the mass loss of the typical TEA-based corrosion inhibitor.

The potential for cobalt leaching was expected to be very low for synthetic coolants with long-life amines, and test work done on the finished coolants confirmed this to be true. Only the commercial additive contains appreciable levels of TEA, and all are fortified with the usual metal deactivator.

3. Synergex™/MIPA combinations

Synergex/MIPA combinations offer enhanced stability and greatly extended fluid life.

Unlike most metalworking fluid additives, Synergex™ amine additives are shown to enhance performance while extending the life of metalworking fluids.

Combinations of tertiary AAA (alkyl alkanolamines) and primary amines provide greater stability than a single amine on its own. Combined with MIPA

(monoisopropanolamine), Synergex amines provide greatly extended fluid life, maintaining higher fluid pH.

To demonstrate, four MIPA/AAA combinations were tested then compared to MIPA/TEA99 (triethanolamine 99) and MIPA/DCHA.

Table 1 contains the test formula.

Table 1	
Coolant formula	%
100-second naphthenic oil	55.00
Soap sulfonate emulsifier	15.00
Alkanolamide emulsifier	15.00
Tall oil fatty acid	2.00
10 HLB nonionic surfactant	3.00
MIPA	5.00
AAA	5.00
Total	100.00

By diluting the fluids to 6%, both the MIPA and AAA are used at 3000 ppm for an amine total of 6000 ppm. Triethanolamine 99 was compared to Amietol™ M12, and DCHA was compared to Synergex, Synergex LA, and Synergex T.

Synergex/MIPA was the best. TEA/MIPA was the worst by far, as Graph 1 shows.

Measuring biological activity using the HMB IV Bacteria Tester from Biotech International, all microbial populations are reported as CFU/mL regardless of whether they are bacteria or mold. Graph 2 shows that, despite lower pH readings, Synergex T and Synergex LA ran much lower CFU counts than DCHA.





Figure 1

Synergex additives make the most of your metalworking fluids.

Synergex amines and Amietol M12 offer true staying power—providing higher reserve alkalinity to neutralize acids formed during the metal-cutting operation, an important property of any metalworking fluid.

Synergex, Synergex T, Synergex LA, and Amietol M12 are less susceptible to degradation by microbial activity, whereas triethanolamine 99 is very susceptible to attack.

Synergex amines and Amietol M12 provide greater protection and less rust in test after test, while triethanolamine 99 and DCHA reveal increased incidence of rust and corrosion.

Figure 1 shows results of cast iron chip tests on fluids halfway through testing (4th challenge). Fluids across the top row are at 6% concentration. Fluids in the middle row are at 4%. Fluids across the bottom row are at 2%. This is where most of the rust appears on those fluids with triethanolamine 99 and DCHA.

These tests clearly demonstrate the usefulness of Synergex™ amine additives and Amietol™ M12.

4. Synergex™ for rust inhibition

Synergex™ neutralizing amine additives can act as key components of water-soluble metalworking fluid rust inhibitors.

With the exit of Corfree® M1 from the marketplace, it is imperative that the amine portion of metalworking fluid rust inhibitors be adjusted to provide maximum contribution to rust protection. Synergex neutralizing amine additives¹ have antirust properties superior to those of commodity ethanolamines such as monoethanolamine (MEA) and triethanolamine (TEA), and they will tolerate higher carboxylate contents (with less water) when used in a water-soluble metalworking fluid rust inhibitor concentrate. One such formula has been used with self-emulsifying esters (SEE's), reverse block polymers, and tramp oil rejecting emulsifiers in semisynthetic metalworking fluid concentrates.

The formula for that rust inhibitor concentrate is given in Table 1:

Component	Description	Wt%	Base val.	Weight equivalent	Base eq total
Water	Water	20.00		119.75	
Synergex	Amine	25.00	479	149.6	269.35
MIPA*	Amine	20.00	748		
			Acid val.		Acid eq total
Corfree® M1	Acid	35.00	509	178.15	178.15
					Base/acid ratio
Total		100.00			1.5

* Monoisopropanolamine

Corfree® is a registered trademark of INVISTA S.a.r.l.

Note that when the acid and base values are taken into consideration, the base to acid ratio is 1.5 to 1. This ratio will be maintained throughout the study. There is an unusually high level of diacid content in this rust inhibitor, and yet it remains a liquid at room temperature. There is no need to store this product in a “hot box” prior to blending it into a metalworking fluid.

Sebacic acid, a readily available potential substitute for Corfree® M1, was used in this study. However, there are other diacids which can be considered, including dodecanedioic acid (DDDA). Note that DDDA is the majority component of Corfree® M1, and DDDA is commercially available (and forecasted to be available for the foreseeable future).² Several diacids and mixtures of diacids, neutralized with varied amines, were studied for their corrosion inhibition properties (see Table 2). Five inhibitor packages were formulated at 15% (w/w) concentrations into sample synthetic light cutting and grinding fluids, along with 15% concentration of TEA and 10% polyalkylene glycol 660, with a balance of water (~60%). The formulated sample fluids were then diluted to 3% and were used to wet cast iron chips placed on filter paper within aluminum pans. The fluid was removed, and the wet chips were evaporated to dryness overnight. Visual results of overnight corrosion are displayed in figure 1. Note that visual inspection of iron chips from various diacids neutralized with the Synergex-MIPA combination show no corrosion, whereas the chips exposed to TEA/MEA neutralized Corfree® M1 fluid display significant rust.

¹ <http://www.eastman.com/Brands/Synergex/Pages/Overview.aspx>

² <http://www.grandviewresearch.com/industry-analysis/dodecanedioic-acid-ddda-industry>

The extent of cast iron chip rust is shown in Figure 1.



The formulas for the rust inhibitors are given in Table 2.

	#1	#2	#3 ³	#4	#5
Description	Emerox® 1195 Synergex™	C10 and C12 Synergex	Corfree® M1 Synergex	Aqualox® 232H	Corfree® M1 MEA TEA
Water	20.00	20.00	20.00	% not known	18.00
Emerox® 1195	35.00				
DDDA		24.00			
Sebacic acid		11.00			
Corfree® M1			35.00	% not known	35.00
Synergex	25.00	25.00	25.00		
MIPA	20.00	20.00	20.00		
TEA 99				% not known	27.50
MEA				% not known	19.50

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Corfree® is a registered trademark of INVISTA S.a.r.l.

Emerox® is a registered trademark of Emery Oleochemicals GMBH.

Because only formula #5 showed rust, we conclude that Synergex/MIPA is a better amine combination than TEA/MEA for preventing rust.

At 15% by weight in the coolant concentrate, the amount TEA at 6% dilution of the metalworking fluid is 9,000 ppm. The contribution of MIPA and Synergex from 15% of the rust inhibitor is 2722 ppm, sufficient for long-life activity. The rust testing was done at 3% just to stress the fluid; otherwise, there would be no rust at all with the fresh dilutions. Because these formulas represent synthetic metalworking fluids, there was no oil in any of the finished fluid formulas. Using Synergex and MIPA to make up the rust inhibitor instead of the more common use of TEA and MEA, allows for not only a more rust resistant formula but also one that has long-life properties.

³ Formula 3 is the same as the rust inhibitor with Synergex/MIPA/Corfree® M1 from Table 1 on page 1.

Semisynthetic metalworking fluid testing

The semisynthetic work was done with a formula that contains 20% oil, 13% sulfonate/nonionic emulsifier, 19% amine/fatty acid soap and 38% water in the concentrate. The water-soluble rust inhibitor made up 6% of the formula, and the amine portion of the soap was evenly divided between primary amine (DGA) and tertiary amine (TEA LF) at 5% each. At an end-use dilution of 6%, there was 3000 ppm each of primary amine and tertiary amine and about 1800 ppm from the amines in the water-soluble rust inhibitor. The pH of the 6% dilution was 8.75 (formula #6), which was generally low for a long-life fluid, so we substituted MDEA for TEA LF and MIPA for DGA in the coolant formula. This resulted in a pH of about 9.20 for the 6% dilution (formula #7).

The remaining formulas for the water-soluble rust inhibitors are given in Table 3.

	#6 and #7	#8	#9	#10	#11	#12
Rust inhibitor ID	Aqualox® 232H	Corfree® M1 Synergex™	Sebacic acid Synergex T	Sebacic acid ⁴ Synergex T Plus	Sebacic acid DMAPF ⁵	Sebacic acid Synergex
Water	% not known	20.00	20.00	20.00	20.00	20.00
Sebacic acid			30.00	30.00	30.00	30.00
Corfree® M1	% not known	35.00				
Synergex		25.00				20.00
MIPA		20.00	20.00	25.00	25.00	20.00
Synergex T			30.00			
Synergex T Plus				25.00		5.00
DMAPF ⁵					20.00	
MEA	% not known				5.00	
TEA	% not known					

Aqualox® is a registered trademark of the Lubrizol Corporation.
Corfree® is a registered trademark of INVISTA S.a.r.l.

A total of seven semisynthetic formulas were tested. Two formulas using Aqualox® 232H, formula #6 where DGA and TEA are the neutralizing amines and the remaining formulas where MDEA and MIPA neutralize the fatty acid in the semisynthetic metalworking fluid. After four challenges, the pH of all seven solutions is 9.0 and above except the original formula with DGA and TEA. The results of the cast iron chip testing are pictured in Figure 2. As expected, formula #6 with DGA and TEA LF showed rust at 3% concentration after four challenges. All but one of the remaining six formulas, in which MDEA and MIPA were substituted for DGA and TEA, did not show any rust at 3% concentration after four challenges. Only formula 9 which uses Synergex T in the rust inhibitor portion of the formula showed a little rust. Synergex T is the most water-soluble of the Synergex neutralizing amine additives.

⁴ There is no Synergex LA (lipophilic amine) in this study because it is too oil soluble to form a water-soluble soap with the usual acids and diacids typically used in these water-soluble rust inhibitors.

⁵ DMAPF is a developmental project. It is the formamide of DMAPA (dimethylaminopropylamine).

Figure 2



Because the semisynthetic formula contains both biocide and fungicide as well as long life amines, it was not expected that any appreciable microbial growth would take place over the course of an 8-week challenge study. The challenges were designed to stress the rust-inhibiting properties of these fluids. More importantly, through four challenges, the odor of these solutions has remained bland and has not taken on any “rotten egg” smell, even though the challenge solution is black and has that very strong odor. When the metalworking solutions are first challenged, they turn grey, but within 2 days, they turn back to a tan color without any odor. The combination of sebacic acid and Synergex™ neutralizing amine additives is more than adequate for rust inhibition in these types of metalworking fluids.

Lastly, it should also be pointed out that long-life metalworking fluids are designed to be used at a specific concentration in order to get the full effect of the synergy between alkyl amino alcohols such as Synergex neutralizing amine additives and antimicrobial additives such as biocides and fungicides. The rust test being run at 3% is one half of the operating concentration of 6%, and yet there is enough rust inhibition even after four challenges. These challenges were specifically designed to demonstrate deterioration of the rust protection of the metalworking fluid mainly through a decrease in pH of the test fluid. The resulting information demonstrates that sebacic acid can substitute for Corfree® M1 in a semisynthetic metalworking fluid by upgrading the amine portion of the water-soluble rust inhibitor over the usual MEA/TEA combination.

The combination of Synergex neutralizing amine additives and MIPA give better rust protection than the combination of MEA and TEA in a water-soluble rust inhibitor.

The use of Amietol® M-12 (MDEA) and MIPA with fatty acids like TOFA has a longer lasting pH boost than TEA LF and DGA.

Sebacic acid and Synergex amine additives are an excellent alternative to Corfree® M1.

5. Synergex™ and Synergex™ T against aluminum corrosion

Aluminum corrosion properties of Synergex™ and Synergex™ T

Synthetic and low oil semisynthetic metalworking fluids were formulated using Synergex™ neutralizing amine additives. These were then checked for aluminum corrosion on two types of aluminum: 6061 and 7075 coupons. The coupons were immersed in the diluted metalworking fluids for 24 hours and the weight loss was measured. The concentration of aluminum which migrates into the fluid during the test is measured by ICP and also reported. Lastly, a visual inspection of the surface of the aluminum coupon is made (see Figures 1 and 2). The concentration of the comparative amine in the end use dilution is at a long life level of 2400 ppm for both the synthetic and semisynthetic formula. Table 1 summarizes the aluminum corrosion data.

Formula type	Low oil semi	Low oil semi	Low oil semi	Synthetic formula	Synthetic formula	Synthetic formula
Comparative amine	Synergex T	Synergex	Corrguard 95 ¹	Synergex T	TEA 99%	Corrguard 95
Dilution	4%	4%	4%	6%	6%	6%
pH	8.45	8.65	8.60	8.05	8.00	8.25
Aluminum alloy	AL 6061	AL 6061	AL 6061	AL 6061	AL 6061	AL 6061
Wt. change, grams	-0.0003	-0.0005	-0.0007	-0.0001	-0.0001	-0.0002
ppm Aluminum	14	30	40	<5	<5	13
Appearance	Dark stain	Dark stain	Dark stain	No stain	No stain	Med. dark
Aluminum alloy	AL 7075	AL 7075	AL 7075	AL 7075	AL 7075	AL 7075
Wt. change, grams	-0.0005	-0.0008	-0.0009	-0.0005	-0.0006	-0.0008
ppm aluminum	14	32	41	<5	<5	17
Appearance	Dark stain	Dark stain	Dark stain	Light/faint	Light/faint	Dark stain

Results

In both the synthetic and semisynthetic formula, Synergex T caused the least amount of aluminum corrosion. Past work has also shown low ferrous dissolution from mild steel (1/20 that of Corrguard 95).

Synergex T has shown very low volatility by means of ASTM E1648 (<8%) and has a very low odor profile and scores well in both global and amine odor tests.

The HLB of Synergex T is 12 and this provides balanced oil/water solubility, allows for surface activity without foam, and gives excellent emulsion stability with good tramp oil rejection.

¹ Corrguard® 95 is a registered Trademark of ANGUS Chemical Company.

Figure 1—Aluminum 6061 synthetic fluid with Synergex T

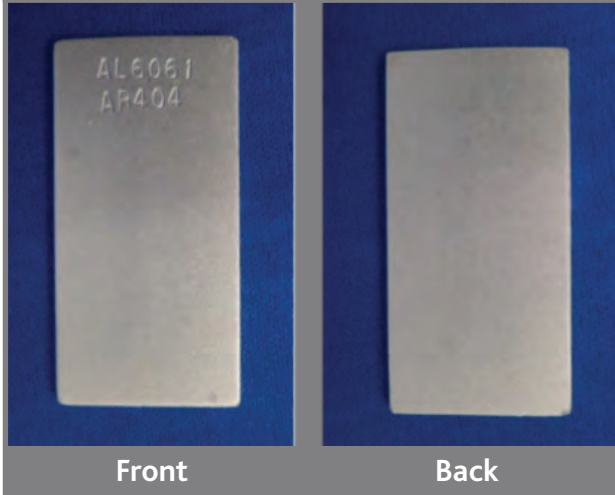


Figure 2—Aluminum 7075 synthetic fluid with Synergex T

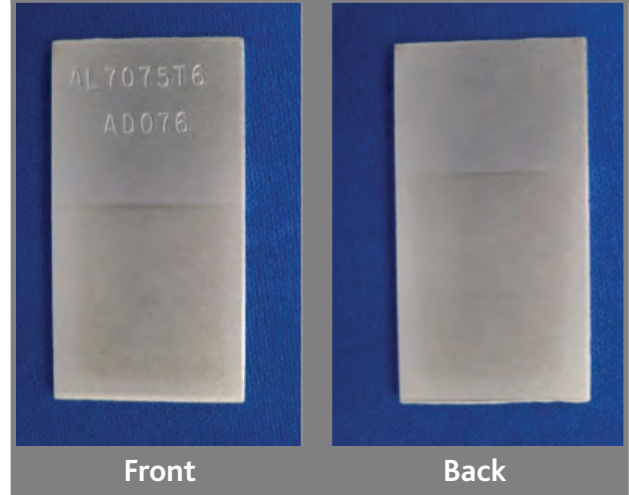


Table 2—Synthetic metalworking fluid for ferrous and nonferrous machining

Phase A		%	
PERFAD™ 3950 ²	16		Multifunctional additive
Synergex T	4		Long-life amine
Neodecanoic acid	3		Rust-inhibiting acid
TAS COR PE 401	0.8		Phosphate ester
Water	10		
Phase B			
Water	49.5		
Amietol M12 (MDEA)	4		Neutralizing amine
MIPA (monoisopropanolamine)	3.2		Neutralizing amine
Isononanoic acid	3		Coupling acid
TAS COR 215A Dicarboxylic acid mix	5.6		Rust-inhibiting diacid
Troyshield FX 40	0.5		Antimicrobial
TT40DC (Cobratec)	0.4		Multi-metal inhibitor

Formulation tips

There is information available about blending with Perfad 3950 from the Croda web site. In general, it must be neutralized with an amine such as Synergex T and blended with cosurfactant before bulk water addition at ambient temperature. For the synthetic version, very little cosurfactant is needed. Inverse solubility polyalkylene glycols can also be added for heavy-duty machining or additional cosurfactants and petroleum oil for a semisynthetic version.

Many cosurfactants have residual acid values which can be neutralized with Synergex and Synergex T.

Summary

Synergex T is a high performance tertiary amine additive for use where secondary amine issues are a concern. Synergex T is a very low-odor, low-VOC amine ideal for use in neutralizing semisynthetic and full synthetic metalworking fluids and emulsion lubricants. The very low vapor pressure and volatility of Synergex T and its molecular stability allows for significantly extended fluid life.

Synergex is a low-odor amine ideal for pH adjustment in semisynthetic and full synthetic emulsion lubricants where secondary amines can be tolerated. Synergex was first introduced to the metalworking market over 30 years ago and gives extended fluid life with an impressive balance of benefit/cost.

² PERFAD™ is a registered Trademark of Croda International Plc.

6. Synergex™ LA lipophilic amine

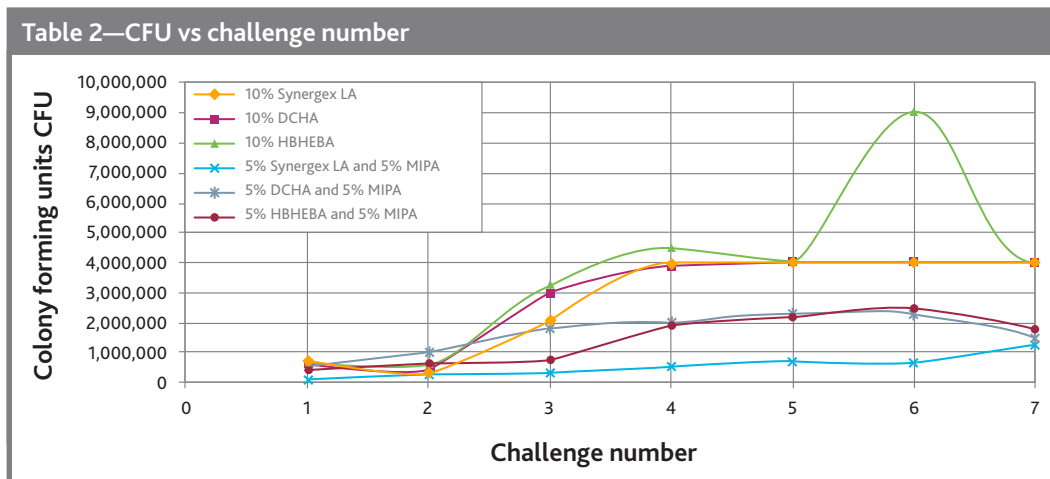
The hydrophobic/hydrophilic amine combination

An excellent hydrophobic alkanolamine for hydrophobic/hydrophilic amine combinations. Synergex LA, especially in combination with a hydrophilic amine, can allow for exceptionally stable emulsions. Combining hydrophobic tertiary amines with hydrophilic primary amines can provide for greater fluid stability than a single amine can on its own. Synergex LA can provide for greatly extended fluid life when combined with MIPA (monoisopropanolamine).

Table 1

Component	Grams	%
1 Naphthenic oil (HyGold 100)	75.00	50.00
2 Soap sulfonate emulsifier (IdaMix D42)	15.00	10.00
3 Nonsulfonate emulsifier (Tas-Sol 37N)	21.00	14.00
4 DIPA TOFA amide 2:1 (amide 5)	5.50	3.67
5 TOFA 28	7.50	5.00
6 Lipophilic amine	7.50	5.00
7 Hydrophilic amine or double dose of lipophilic amine	7.50	5.00
8 Polymeric ester (Syn-Ester GY-25)	3.00	2.00
9 Tolyltriazole 50% (Preventol CI 7-50)	0.50	0.33
10 Antifoam (SurTec KE-131)	0.30	0.20
11 Biocide (Bioban P-1487)	1.00	0.67
12 Odorant (Ida-Soil SM 101)	0.60	0.40
13 Fungicide (Troy Shield FX 40)	0.60	0.40
14 Carboxylate rust inhibitor (Aqualox 232H)	5.00	3.33
Grand totals	150.00	100.00%

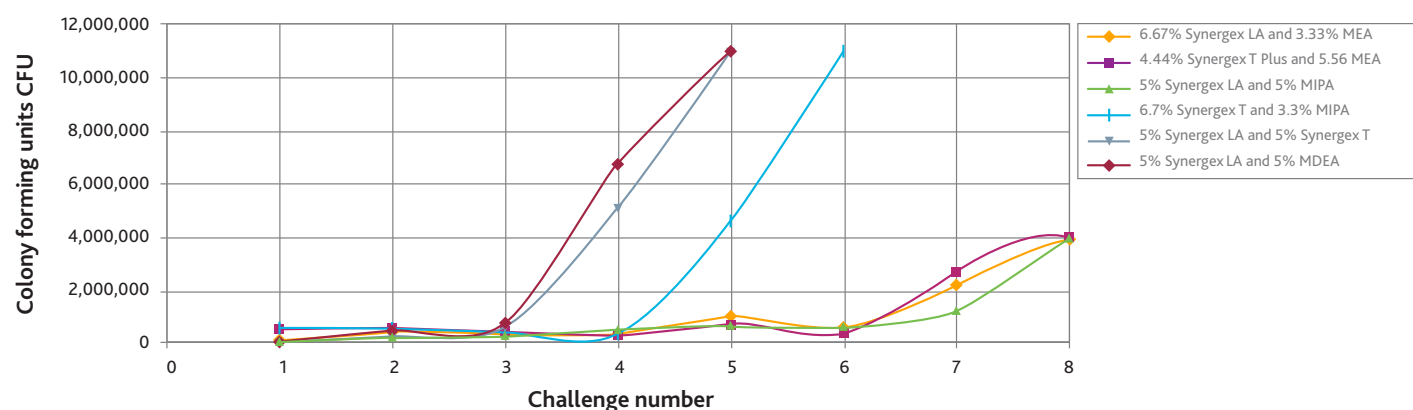
Table 2—CFU vs challenge number



Synergex™ LA is an ideal hydrophobic amine for metalworking

As Table 4 illustrates, Synergex LA provides faster wetting time on aluminum when compared to many other amines. A balanced combination of Synergex LA with MIPA can provide for greatly extended fluid life (see formula below).

Table 3 — CFU vs challenge number



Initially there is 100 mL of fluid. At each challenge, 10 mL is taken for the CFU testing and 6 mL is taken for the rust testing; for the 4th and 8th challenge, an additional two drops is taken for the aluminum wetting test. About 5 mL is returned to the jar after soaking in the cast iron chips for 30 minutes. CFU is taken by the HMB method and pH is taken with a pH meter. Finally, 11 mL of challenge solution is charged to the jar for the next challenge. The jars are incubated at 95°F.

Table 4

Cast iron chips on paper	Aluminum wetting time (seconds) hard water	Aluminum wetting time (seconds) soft water
TEA (control)	450	49
DCHA	155	40
Synergex LA	141	29
Synergex T Plus	210	43
Synergex T	389	79
MDEA	908	210
HBHEBA	179	67

TEA = triethanolamine

DCHA = dicyclohexylamine

HBHEBA = N-2-hydroxyethyl N-2-hydroxybutyl butylamine

MDEA = methyldiethanolamine

MIPA = monoisopropanolamine

MEA = monoethanolamine

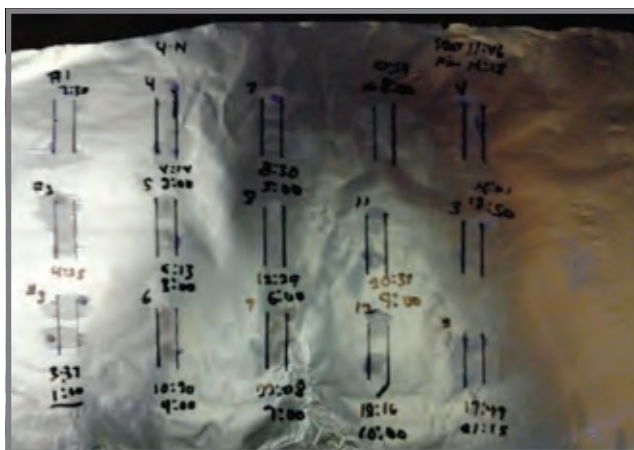
Two drops of diluted fluid are deposited on the aluminum foil and the time to spread out to the prescribed lines is timed and reported as the "seconds aluminum wetting time."

HOSS emulsion fluid used for studies

Table 5

Coolant formula	%	Parts
HyGold 100 naphthenic base oil	55.00	55.00
Ida-Mix D42M sulfonate emulsifier	15.00	15.00
Tas Sol 37N nonsulfonate emulsifier	15.00	15.00
Tall oil fatty acid	5.00	5.00
Amine	10.00	10.00
	100.00	100.00

6% dilution to 6000 ppm amine in fluid



Contact



To learn more about Synergex, visit www.SynergexAmine.com.

To place an order in North America or for more information, contact one of our distributors:

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