Multi-functional amine additives in metalworking fluids (MWF)

Formulation concepts incorporating Eastman Synergex™ and MDEA

May 2026

EASTMAN | Synergex™

Amine choice influences

pH stability, corrosion protection strategy, and overall fluid life.

Different MWF types require

different amine balance for performance, emulsion and concentrate stability.

It is difficult to create

an optimized balance using only one amine and formulators typically utilize two or three in each formulation.

This program summarizes example formulations, different amine combinations, and their impact on metalworking fluid performance.

Why amine selection matters in metalworking fluids.

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Eastman amines for metalworking fluids

	Amietol™ M12 (MDEA)	Synergex™	Synergex™ T	Synergex™ LA
Type	Tertiary	Secondary	Tertiary	Tertiary
Neutralizing power (mEquivalents/g)	8.4	8.5	6.2	5.8
Odor	Low	Low	Very low	Low
Extended fluid Life	Neutral	Excellent	Good	Good
Iron corrosion	Excellent	Good	Good	Good
Aluminum staining	Excellent	Good	Excellent	Good

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Eastman amines for metalworking fluids

	Amietol™ M12 (MDEA)	Synergex™	Synergex™ T	Synergex™ LA
Boiling point	247°C	199°C	283°C	230°C
Melting point	-21°C	-18°C	-70°C	-75°C
Flash point	138°C	96°C	141°C	96°C
Mw	119.2	117.2	161.3	173.3
Vapour pressure	<0.01 mmHg	<0.1 mmHg	<0.01 mmHg	<0.1 mmHg
pKa	8.7	10.0	8.9	9.9
Labelling				

Always refer to the relevant SDS on our website: [Eastman Products and Markets | Innovative Materials]

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The role of Eastman amine additives

Formulations created utilising Synergex T, Synergex LA and MDEA

Use as part of a balanced system including corrosion inhibitors, emulsifiers, coupling agents, and hard-water stabilizers.

Typical formulation objectives:

- Concentrate stability
- Emulsion clarity/appearance/stability/longevity
- Ferrous, aluminium & yellow metal corrosion protection
- Hard-water stability
- Low foam propensity

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Formulation concepts

Formulations are designed to:

- be boron and MIPA (isopropanolamine) free
- minimize the use of bactericides
- optimize the performance characteristics of metalworking fluids, using a combination of amines

1. **Low oil semi-synthetic (micro) emulsion**
2. **Medium oil semi-synthetic (micro) emulsion**
3. **High oil / ester (macro) emulsion**

Additives and their functions
(abbreviations)

Function	RM Type
Ferrous corrosion inhibitor	FCI
Non-ferrous corrosion inhibitor	NFCI
Yellow metal corrosion inhibitor	YMCI
pH stabilizer/ neutralizing amine	PHNA
Corrosion inhibitor package	CIP
Coupling agent	CA
Fungicide	FA
Defoamer	DA
Diluent	D
Lubricity additive	LA
Lubricant	LB
Emulsifier system	ES
Hard water stabilizer	HWS

Product 1 (EV 118)

Low oil, semi-synthetic (micro) emulsion

- Designed to show the versatility of Eastman amine additives
- Three are used in this formulation: **Synergex T, Synergex LA, and MDEA**
- Option to increase water content of concentrate
- High performance, general application fluid
- Ready to perform

Low oil semi-synthetic (micro) formulation (EV 118)

Component (chemical / descriptor)	Wt%	RM Type
Synergex LA	3.9	PHNA
Tri hexanoic acid based inhibitor	3.8	FCI
Phenoxyethanol	5.8	CA
Synergex T	4.8	PHNA
Monoethanolamine (MEA)	3.1	PHNA
Amietol M12 (MDEA)	3.5	PHNA
Benzotriazole	0.5	YMCI
Iodocarbamate 40%	0.7	FA
Ethoxylated/Propoxylated fatty alcohol	9.8	ES
Ethoxylated alkanolamide	1.9	FCI
Distilled Tall Oil (DTO)	4.7	LA
Ethoxylated phosphate ester	0.9	NFCI
Ether carboxylate C9/C10	2.6	HWS
Dipropylene glycol methyl ether	4.3	CA
Dicarboxylic acid	1.5	FCI
Naphthenic base oil (22 cSt @40°C)	22.0	LB
Water	26.0	D
Siloxane antifoam	0.2	DA

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Low oil semi-synthetic (micro) formulation (EV 118)

Laboratory test characteristics

Emulsion type:

- Stable emulsions even in hard water
- 50, 200, 500 ppm (as $CaCO_3$) water

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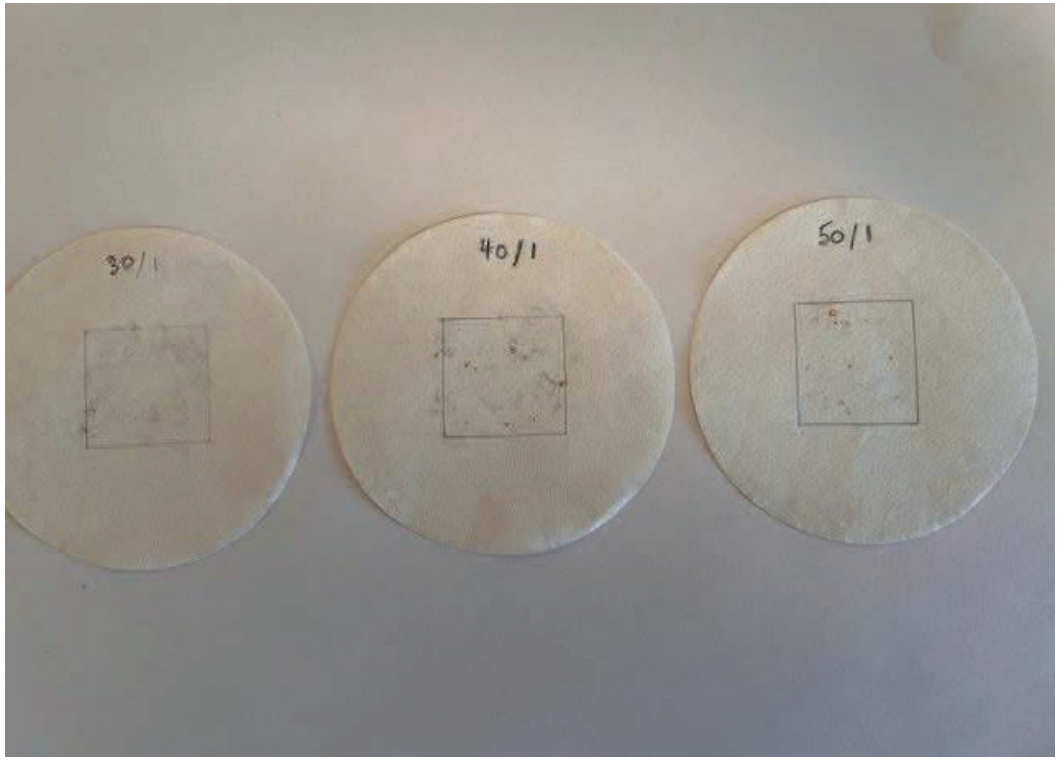
Low oil semi-synthetic (micro) formulation (EV 118)

Laboratory test characteristics



Ferrous corrosion test:

- Good corrosion protection at various concentrate dilutions
- Filter paper (IP 287) – 30/1, 40/1, 50/1

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Low oil semi-synthetic (micro) formulation (EV 118)

Development Summary

- Following the creation of several formulations, the test program centered on preferred option EV 118.
- Designed to utilize Synergex T, Synergex LA, and MDEA to optimize performance of a ‘general purpose’ semi-synthetic emulsion.
- Technically, the EV 118 formulation was developed to allow the addition of water up to 50% by weight in the concentrate (commercial option).
- Preliminary laboratory testing indicates viability for general purpose applications.
- Raw materials commonly available in Europe were utilized in the formulation.

Product 2 (EV 217)

Medium oil, semi-synthetic (micro) emulsion

- High performance product for **non-ferrous** applications
- Based around the performance of **Synergex T**
- Strong emulsion stability and longevity
- Low staining potential on aluminum and yellow metals

Medium oil semi-synthetic (micro) formulation (EV 217)

Component (chemical / descriptor)	Wt%	RM Type
MDEA	3.5	PHNA
Tri hexanoic acid based inhibitor	3.5	FCI
Phenoxyethanol	5.4	CA
Synergex T	6.5	PHNA
Monoethanolamine (MEA)	3.5	PHNA
Benzotriazole	0.5	YMCI
Iodocarbamate 40%	0.7	FA
Alcohol ethoxylate (3 mol)	1.5	ES
Ethoxylated/propoxylated fatty alcohol	9.8	ES
Ethoxylated alkanolamide	1.8	FCI
Distilled tall oil (DTO)	4.7	LA
Ethoxylated phosphate ester	1.2	NFCI
Ether carboxylate C9/C10	2.5	HWS
Dipropylene glycol methyl ether	4.0	CA
Dicarboxylic acid	1.0	FCI
Iso tridecanol	0.5	CA
Castor oil, polymerized	3.5	LA
Naphthenic base oil (22 cSt @40°C)	34.4	LB
Water	11.3	D
Siloxane antifoam	0.2	DA

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Medium oil semi-synthetic (micro) formulation (EV 217)

Laboratory test characteristics

Emulsion type:

- Stable emulsions even in hard water
- 50, 200, 500 ppm (as $CaCO_3$) water

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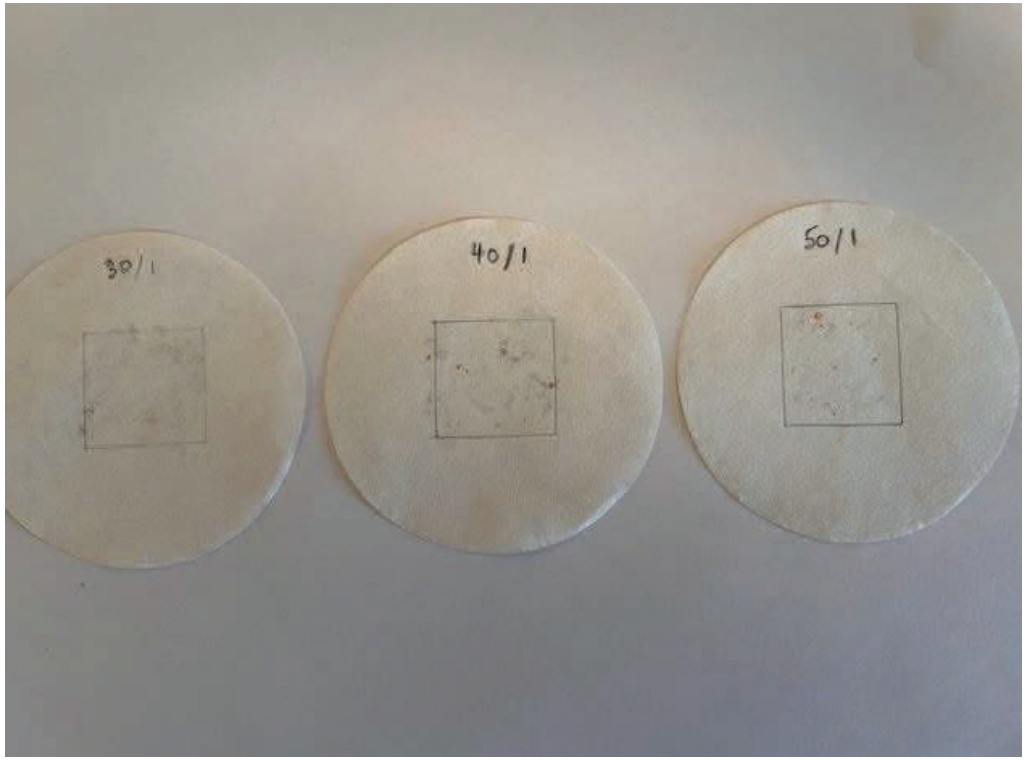
Medium oil semi-synthetic (micro) formulation (EV 217)

Laboratory test characteristics



Ferrous corrosion test:

- Good ferrous metal protection across different concentrations
- Filter paper (IP 287) – 30/1, 40/1, 50/1

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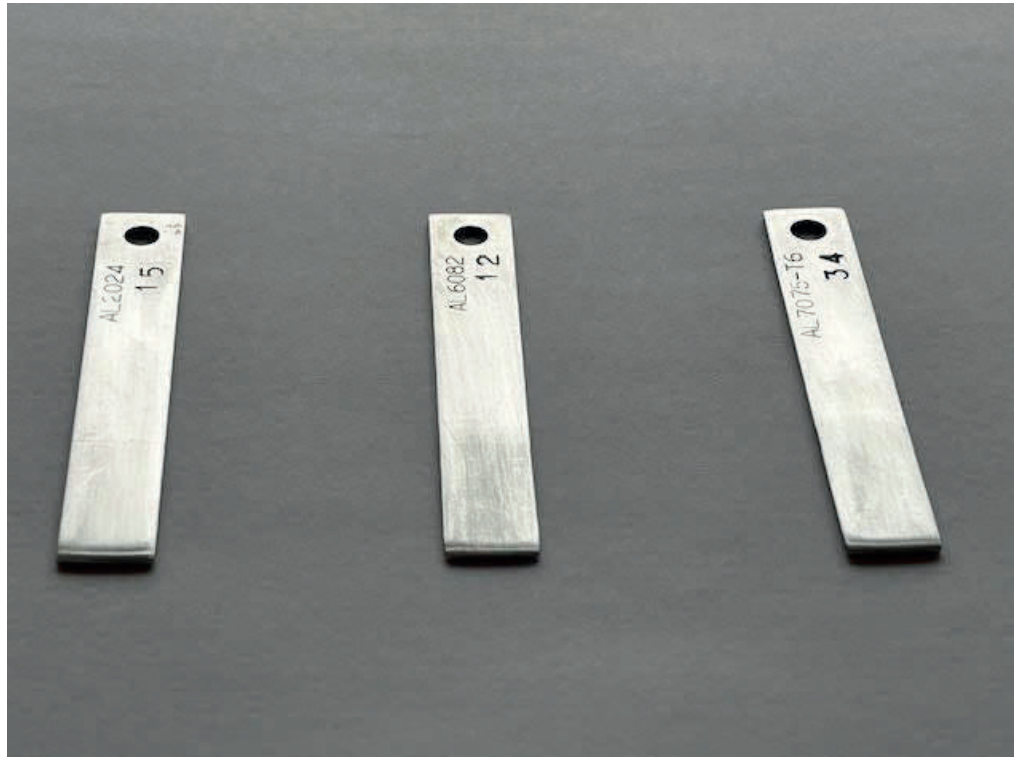
Medium oil semi-synthetic (micro) formulation (EV 217)

Laboratory test characteristics



Aluminum corrosion test:

- Very low staining across 3 different Al alloys
- Left to right: 2024/6082/7075
- 48 Hours semi-immersion – 100 ppm water

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Medium oil semi-synthetic (micro) formulation (EV 217)

Laboratory test characteristics

Yellow metal corrosion test:

- No staining
- Copper & brass – 48 Hours 100 ppm water

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Medium oil semi-synthetic (micro) formulation (EV 217)

Laboratory test characteristics

Test method	Assessment of product service life through circulation in a mini-sump system
Mini-sump temperatures	25°C
Volume of inoculant added each week	100 mL from weeks 1 to 7. 150 mL from weeks 8 to 12
Inoculant bacterial & fungal count	Bacteria: 10^6 CFU per mL / Fungus: 10^6 CFU per mL
Water hardness	<50 ppm total hardness
Concentration of test fluids	5% measured by refractometer

Emulsion longevity test:

- 12 weeks – pH / bacterial stability

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Medium oil semi-synthetic (micro) formulation (EV 217)

Laboratory test characteristics

Emulsion longevity test:

- 12 weeks – pH/bacterial stability

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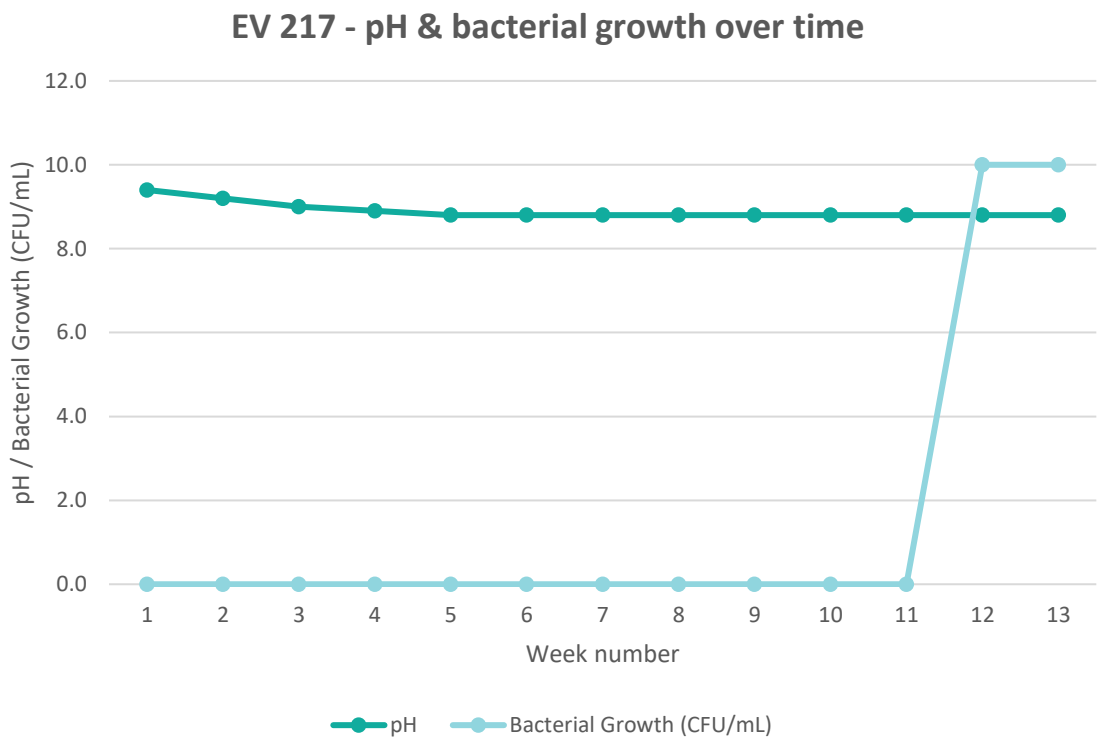
Medium oil semi-synthetic (micro) formulation (EV 217)

Laboratory test characteristics

Emulsion longevity test:

- Stable fluid for 12 weeks
- 12 weeks – pH/bacterial stability



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Product 3 (EV 321)

High oil, ester (macro) emulsion

- Superior performance product for multi-metal applications
- Based around the performance of **Synergex LA** and compared with DCHA (EV 322)
- Very good emulsion and pH stability
- Reduced migration of amines to oil phase in use

High oil/ester (macro) formulation with Synergex LA (EV 321)

Component (chemical / descriptor)	Wt%	RM Type
MDEA	2.0	PHNA
Dodecanedioic acid	2.2	FCI
Phenoxyethanol	4.5	CA
Synergex LA	4.0	PHNA
Iodocarbamate 40%	0.5	FA
Alcohol ethoxylate (3 mol)	1.5	ES
Ethoxylated/propoxylated fatty alcohol	9.6	ES
Ethoxylated alkanolamide	1.8	FCI
Distilled Tall Oil (DTO)	4.7	LA
Ethoxylated phosphate ester	0.6	NFCI
Ether carboxylate C9/C10	2.5	HWS
Dipropylene glycol methyl ether	3.0	CA
Dicarboxylic acid	1.0	FCI
Hexanoic acid / amine-based corrosion inhibitor	8.9	CIP
Castor oil, polymerised	3.5	LA
Naphthenic base oil (22 cSt @40°C)	40.0	LB
Water	9.5	D
Siloxane antifoam	0.2	DA

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High oil/ester (macro) formulation with DCHA* (EV 322)

Component (chemical / descriptor)/ amine	Wt%	RM Type
MDEA	2.0	PHNA
Dodecanedioic acid	2.2	FCI
Phenoxyethanol	4.5	CA
***Dicyclohexylamine (DCHA)**	4.0	PHNA
Iodocarbamate 40%	0.5	FA
Alcohol ethoxylate (3 mol)	1.5	ES
Ethoxylated/propoxylated fatty alcohol	9.6	ES
Ethoxylated alkanolamide	1.8	FCI
Distilled tall oil (DTO)	4.7	LA
Ethoxylated phosphate ester	0.6	NFCI
Ether carboxylate C9/C10	2.5	HWS
Dipropylene glycol methyl ether	3.0	CA
Dicarboxylic acid	1.0	FCI
Hexanoic acid / amine-based corrosion inhibitor	8.9	CIP
Castor oil, polymerized	3.5	LA
Naphthenic base oil (22 cSt @40°C)	40.0	LB
Water	9.5	D
Siloxane antifoam	0.2	DA

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EV 321 vs EV 322

What changes?

Primary variable is the amine choice: Synergex LA (EV 321) vs Dicyclohexylamine (DCHA) (EV 322)

The rest of the key components (including emulsifier system, hard-water stabilizer, corrosion inhibitor package, base oil, and defoamer) remain unchanged.

To include DCHA, maximum 2% tall oil must be added.

Synergex LA is easier than DCHA to incorporate into formulation.

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High oil/ester (macro) formulation (EV 321)

Laboratory test characteristics

Emulsion type:

- Stable emulsions even in hard water
- 50, 200, 500 ppm (as $CaCO_3$) water

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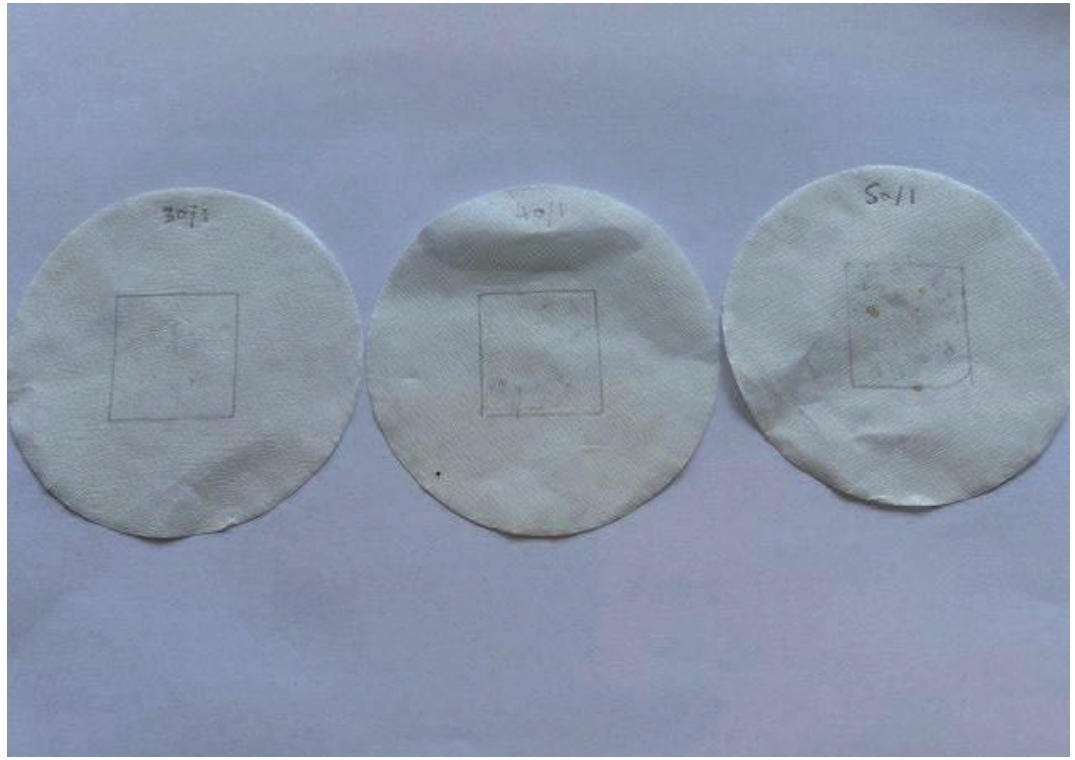
High oil/ester (macro) formulation (EV321)

Laboratory test characteristics



Ferrous corrosion test:

- Good performance across various dilutions
- Filter paper (IP 287) – 30/1, 40/1, 50/1

High oil/ester (macro) formulation (EV 321)

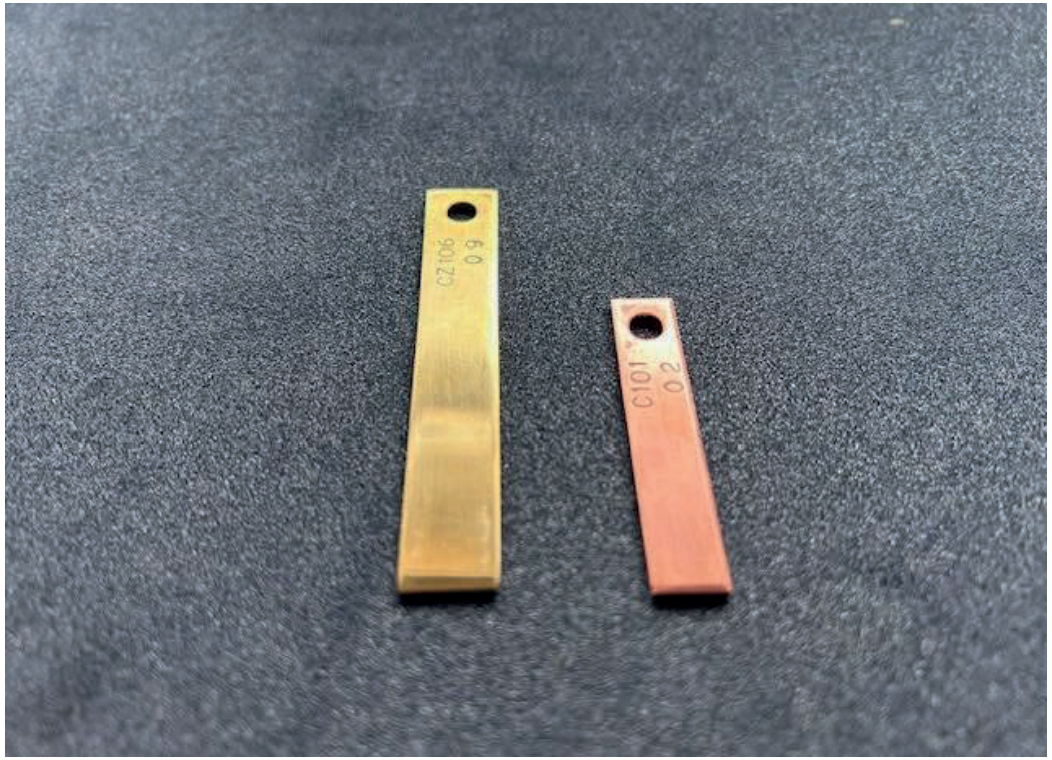
Laboratory test characteristics

Aluminum corrosion test:

- Low staining on 3 different Al alloys
- Left to right: 2024/6082/7075
- 48 Hours semi-immersion – 100 ppm water

High oil/ester (macro) formulation (EV 321)

Laboratory test characteristics



Yellow metal corrosion test:

- No staining
- Copper/Brass – 48 hours 100 ppm water

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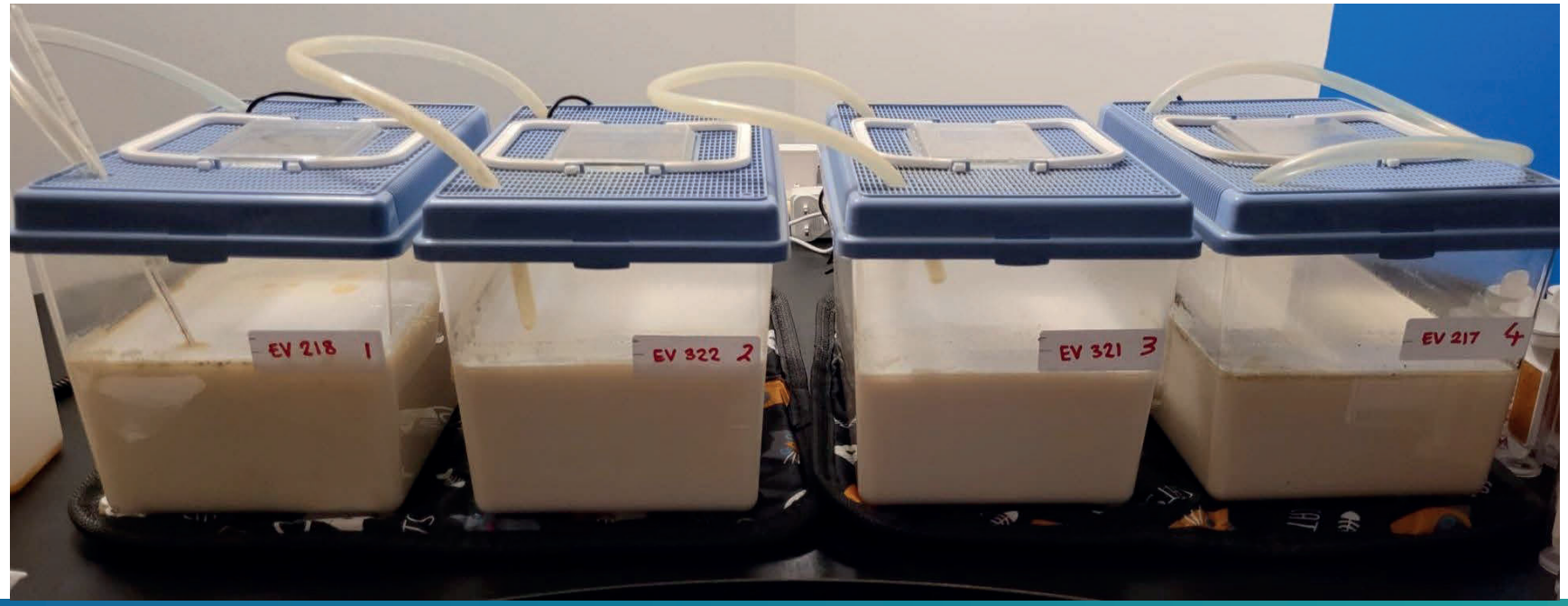
High oil/ester (macro) formulation (EV 321)

Laboratory test characteristics

Emulsion longevity test:

- 12 weeks – pH / bacterial stability



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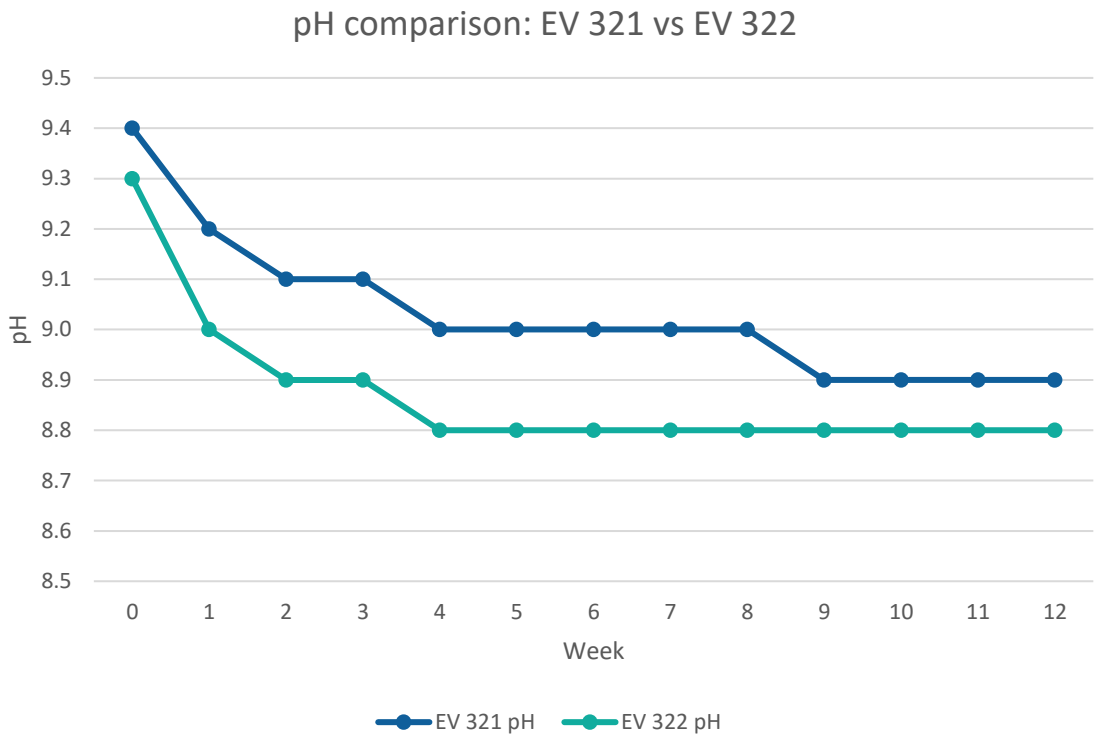
High oil/ester (macro) formulation (EV 321)

Laboratory test characteristics

Emulsion longevity test:

- EV 321(Syn LA) v EV 322 (DCHA)
- Synergex LA performed well
- 12 weeks – pH/bacterial stability



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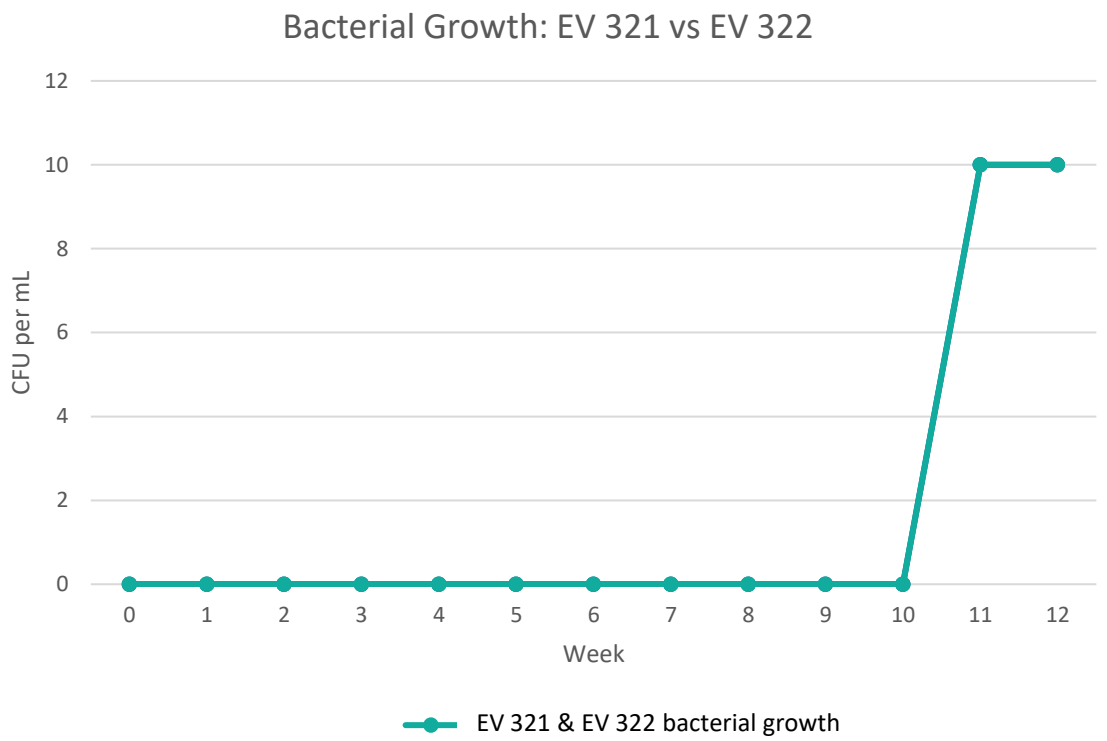
High oil/ester (macro) formulation (EV 321 & EV 322)

Laboratory test characteristics

Emulsion longevity test (fluid stability):

- Synergex LA & DCHA perform similarly
- Minimal bacterial growth up to 12 weeks with both amines



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Eastman Synergex amines in real world, ready-to-use metalworking fluid formulations

Conclusion

- Synergex amines can be key high-performance multi-functional amine additives for novel metalworking fluid formulations.
- Amine combinations are critical to the development of modern MWF products, as evolving regulations continue to limit legacy raw material options.
- Synergex amines support the development of robust concentrates and stable emulsions when paired with appropriate other additives and components.
- Specifically, Synergex LA can be a practical alternative to DCHA within current boron-free metalworking fluids.
- Eastman can help you identify the right amine combinations for your needs.

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Thank you.

For further information:

- Synergex | Multifunctional Amine Additives | Eastman
- Contact Us | Inquiries | Eastman
- Contact your account manager
- Contact your distributor (see right)

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- About Smart Oil (China)
- GB Chemie – Chemie Großhandel, Chemikalien Großhandel, Chemie, Chemische Producte, Vertrieb chemische Produkte, Distribution chemische Produkte (DACH)
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