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Synergex™

Synergex™ multifunctional amine additives for metalworking fluids

STLE 2019 Nashville

TAM-9859 05/19

Enhancing the quality of life in a **material way**

- Fortune 500 specialty materials company with 2018 revenue of ~$10B
- Global manufacturer and marketer of advanced materials and specialty additives
- Operates four business segments
- Global team of ~14,500
- Serving customers in >100 countries

A global industry **leader**

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Where did the **amines come from**?

2006	Air Products sells amines business to Taminco
2007	Arkema sells specialty amines business to Taminco
2014	Eastman acquires Taminco in the second largest acquisition in Eastman history

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Today's discussion

- Amines in Metalworking Fluids
- Benefits of Alkanolamines
  - Biostability
  - Emulsion Stability
  - Corrosion Inhibition
- The Synergex Products
  - Synergex
  - Synergex T
  - Synergex LA
- The Future
  - New amine additives - is there a need?
  - C8/10 amides for metalworking
- Summary

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Use of amines in metalworking fluids

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Amines are **MWF-soluble bases** that are:

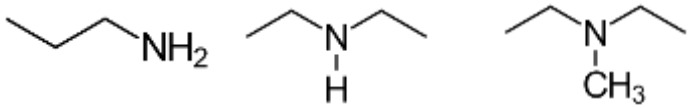
- ✓ More compatible than an inorganic base
- ✓ Compatible with O/W and W/O emulsions

Amines are *necessary* to adjust the pH of functional fluids

Benefits of alkanolamines

Amine choice is a ***formulator's decision.***

Examples of amines



Primary
1°

Secondary
2°

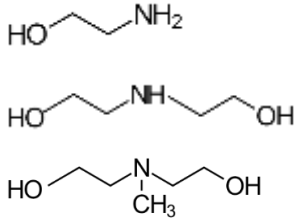
Tertiary
3°

A. Hydrophobic versus hydrophilic

B. Volatile (odorous) versus non-VOC

C. Alkanolamine versus alkylamine

D. Multifunctional (e.g., corrosion inhibitor) versus pH only



Monoethanolamine

Diethanolamine

N-Methyldiethanolamine

What are the ideal properties of an amine?
It depends

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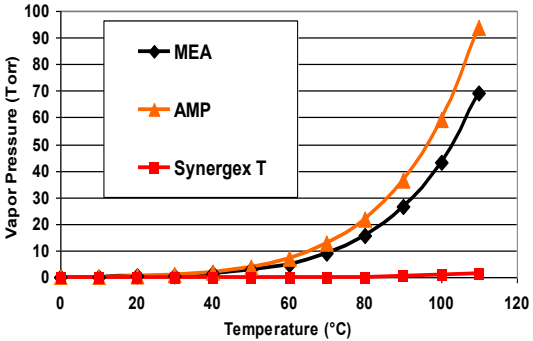
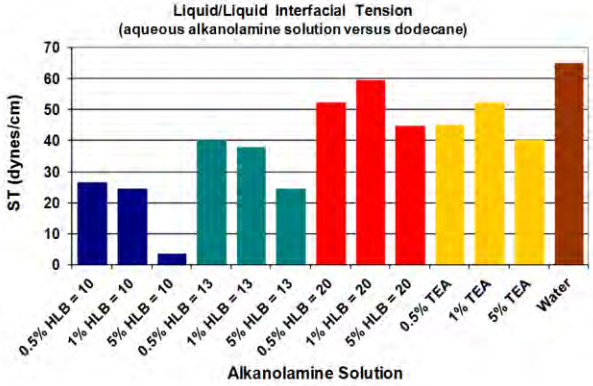
Low odor/volatility



Emulsion stability



Corrosion

Biostability

Alkanolamines provide:

- ✓good base strength and capacity at
- ✓reasonable cost with
- ✓low VOC contribution and low odor

The Synergex™ product line

The Synergex product line

- **Synergex**—excellent supplementary biostability, low volatility and odor, good corrosion inhibition, colloid stabilization
- **Synergex T**—good supplementary biostability, tertiary amine, very low volatility and odor, colloid stabilization
- **Synergex LA**— tertiary amine and capable DCHA replacement that pairs well with lower-MW primary alkanolamines such as MEA and MIPA
- **Synergex T Plus/Premier**: available if there is sufficient customer demand
- THE FUTURE?

Amines: key physical properties

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Amine	MW	EW	pKa	mg KOH/g	HLB	BP (°C)
Synergex T	161.24	161.24	8.9	347	12	285 (normal)
Synergex	117.19	117.19	9.7	478	10	200 (normal)
Synergex LA	173.30	173.30	10.3	324	6	230 (normal)
MDEA	119.16	119.16	8.8	471	17	247 (normal)

- **MW =** molecular weight (g/mole)
- **EW =** equivalent weight (g per equivalent of amine)
- **pKa =** negative log of the equilibrium constant for dissociation of the protonated amine (water, RT)
- **mg KOH/g** = mass of KOH with same number of moles as 1 gram of the amine
- **HLB =** calculated floor function of {60/MW} x 20 for monoethoxylate and {104/MW} x 20 for diethoxylate
- **BP =** boiling point; normal designates a pressure of 1 atmosphere

Synergex and biostability

Fluid user and formulator—working together to optimize biostability

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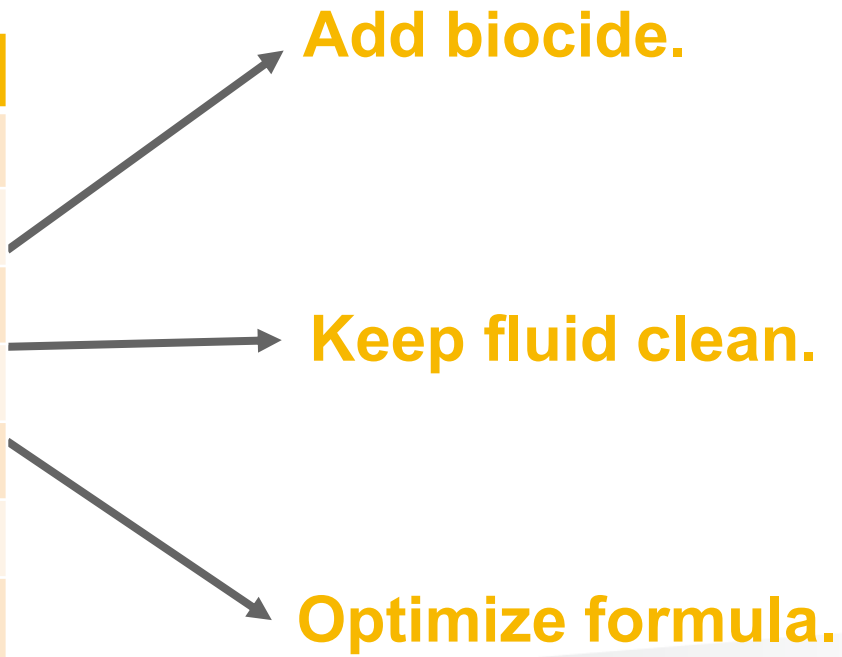
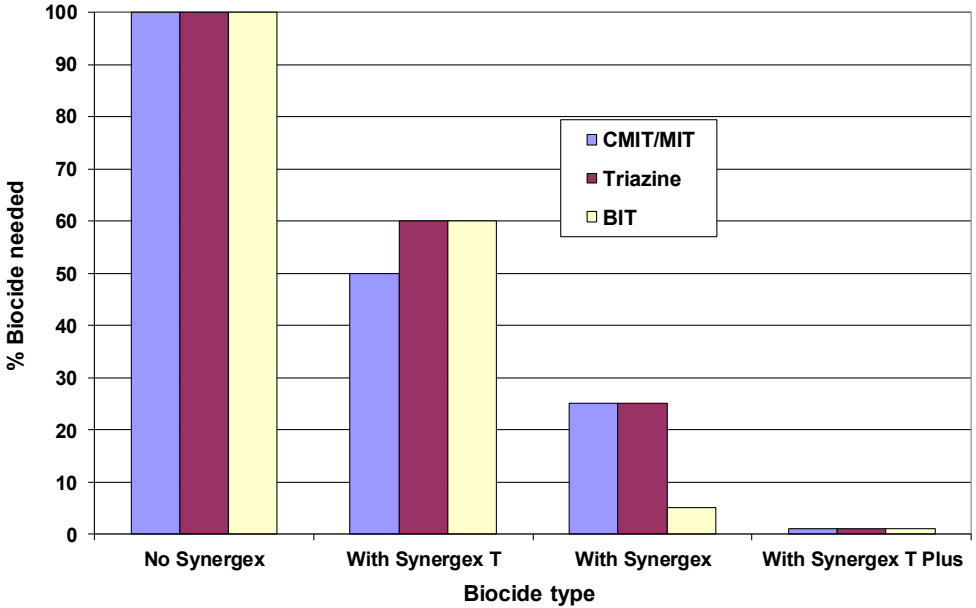
Emulsion fluid	
100 SUS oil	72 g/kg
60% sulfonated oil	72 g/kg
DEA fatty acid amide	72 g/kg
Tall oil fatty acid	72 g/kg
BASF 17R4	24 g/kg
Triethanolamine (85%)	100 g/kg
Alkanolamine	**40 g/kg**
Water	Balance



Biocide reductions possible with Synergex products



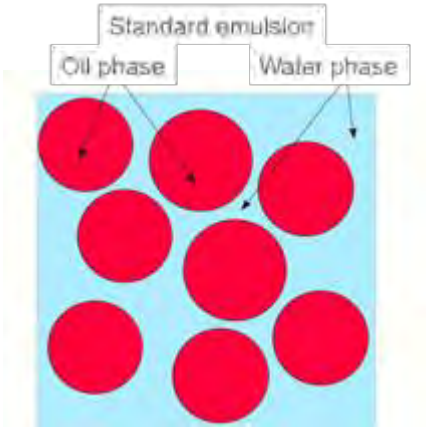
Observations

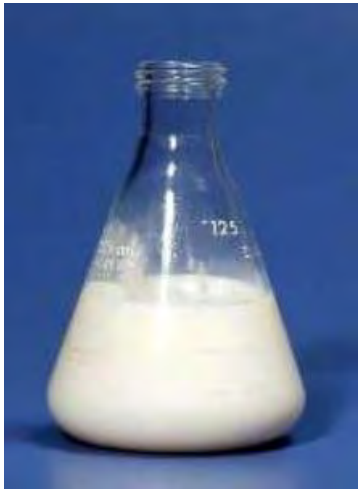
- All Synergex products can be used as part of a biostable, low-VOC metalworking fluid.
- Fluids based on the Synergex *N*-alkyl alkanolamines do not stain aluminum (AL 2024 pieces dipped in the fluids shown; MDEA for reference).

Synergex T and MDEA | MDEA

Synergex and emulsion stability

Emulsion basics

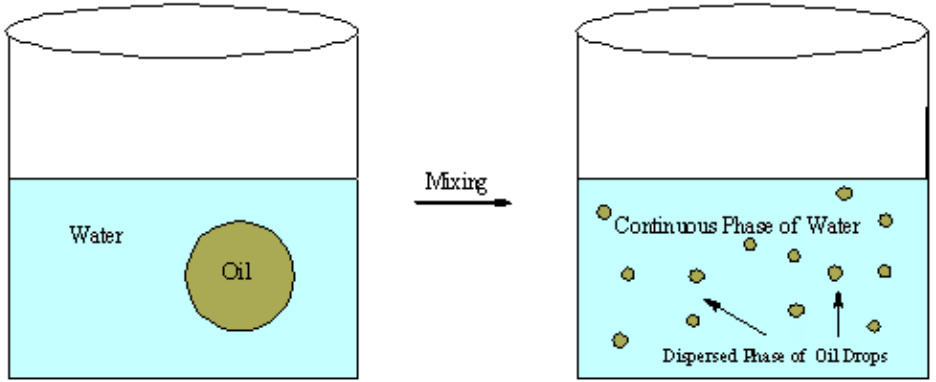




Phase		Dispersed phase		
		Gas	**Liquid**	**Solid**
Continous phase	**Gas**	None (miscible)	Aerosol (mist)	Solid aerosol (smoke, dust)
	Liquid	Foam	Emulsion (O/W, W/O)	Solid (dispersion)
	Solid	Solid foam	Gel	Solid sol

Why is **liquid/liquid interfacial tension** important?

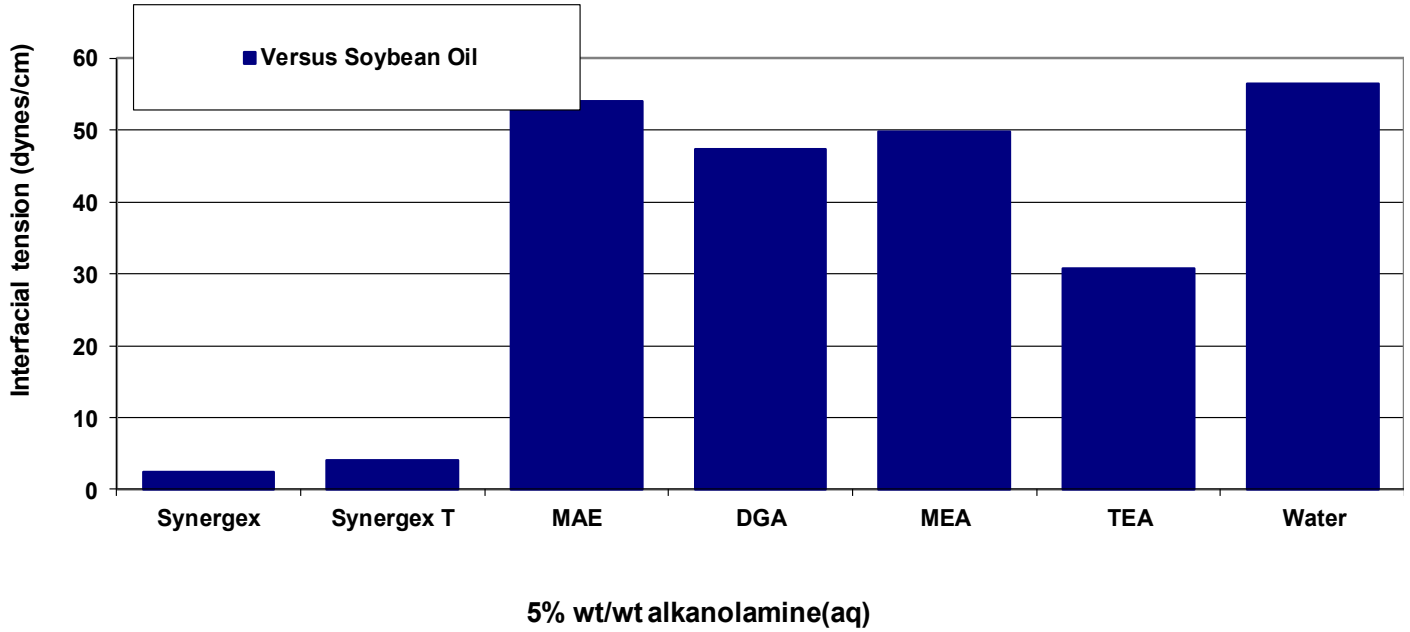
Emulsions are destabilized by a large increase in oil/water surface area



Energy difference between O/W emulsion and two separate oil and water phases

$$\Delta E = (\gamma_{water/oil})\Delta A_{water/oil} - T\Delta S_{mixing}$$

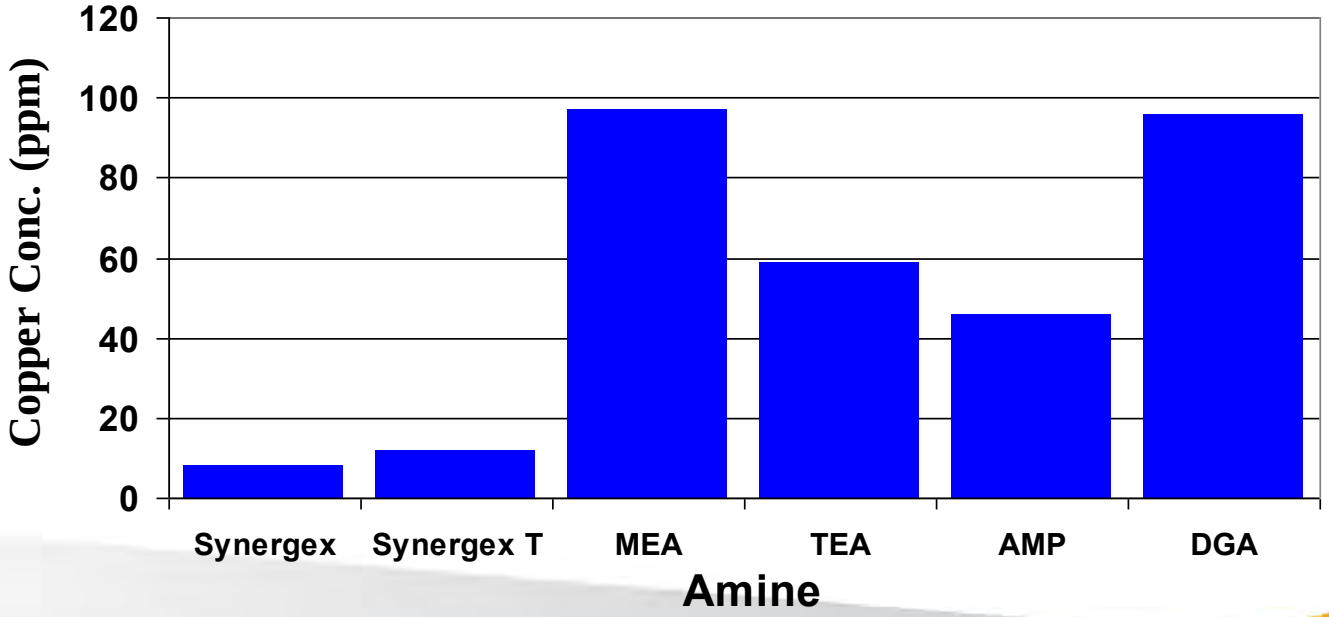
Liquid/liquid interfacial tension in dynes/cm



Synergex: excellent corrosion inhibitor

Passive dissolution of copper

(0.3 M amine, 0.2 M octanoic acid, 8 days)
(Unleaded brass CA-260, pH adjusted to 8.5 with H_3PO_4/KOH)



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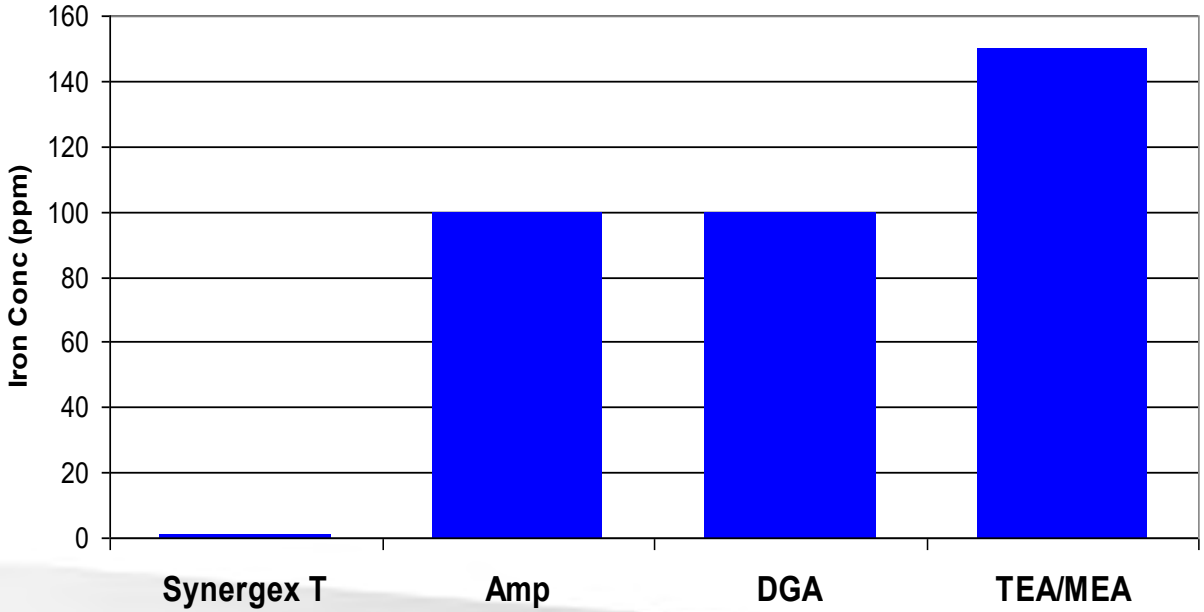
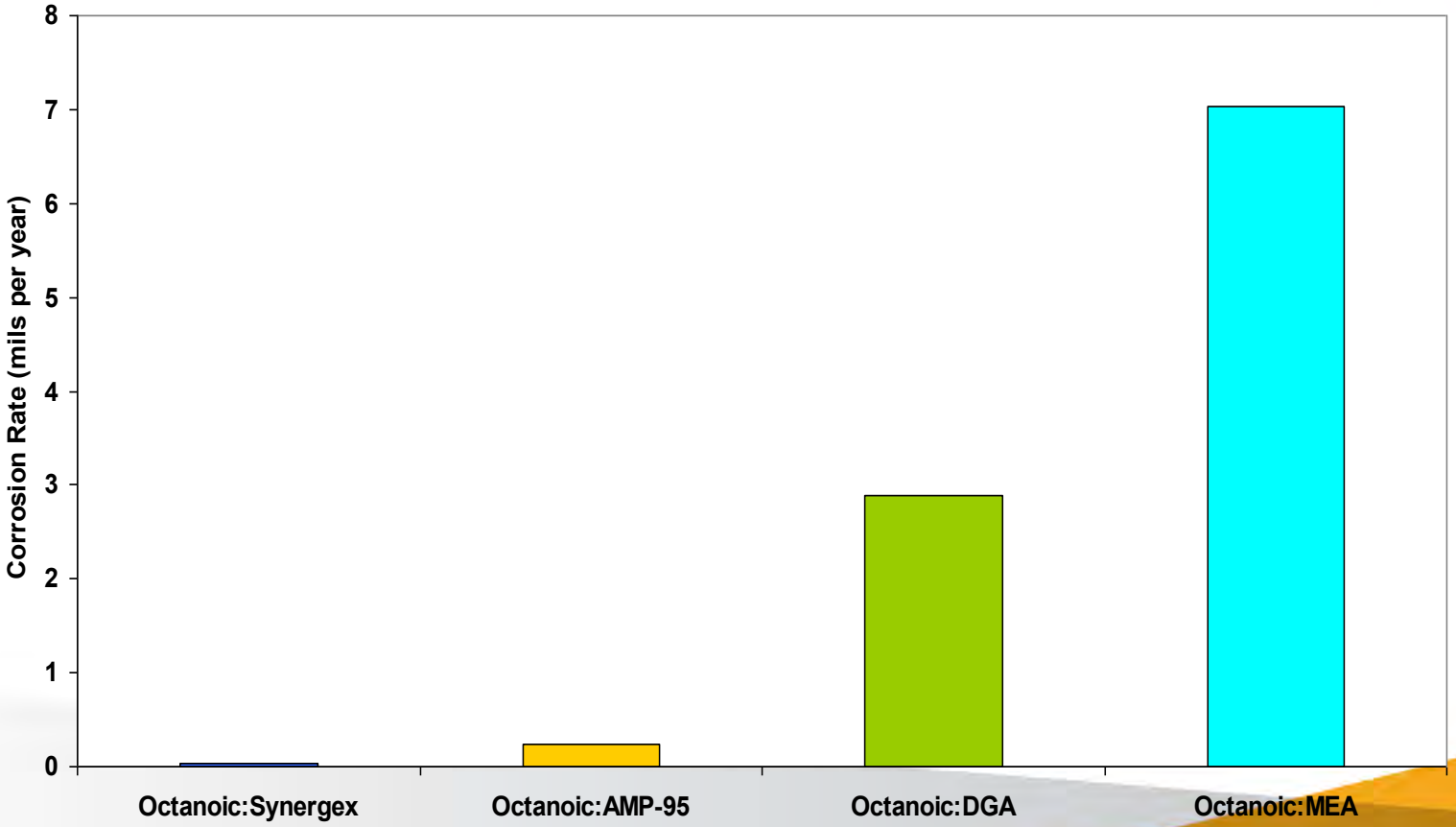
Passive ferrous dissolution from mild steel panels

(32g/L amine, 36 g/L of 1/1 caprylic/dodecandioic acids)
(pH = 8.5 adjusted with KOH or H_3PO_4 for 30 days)

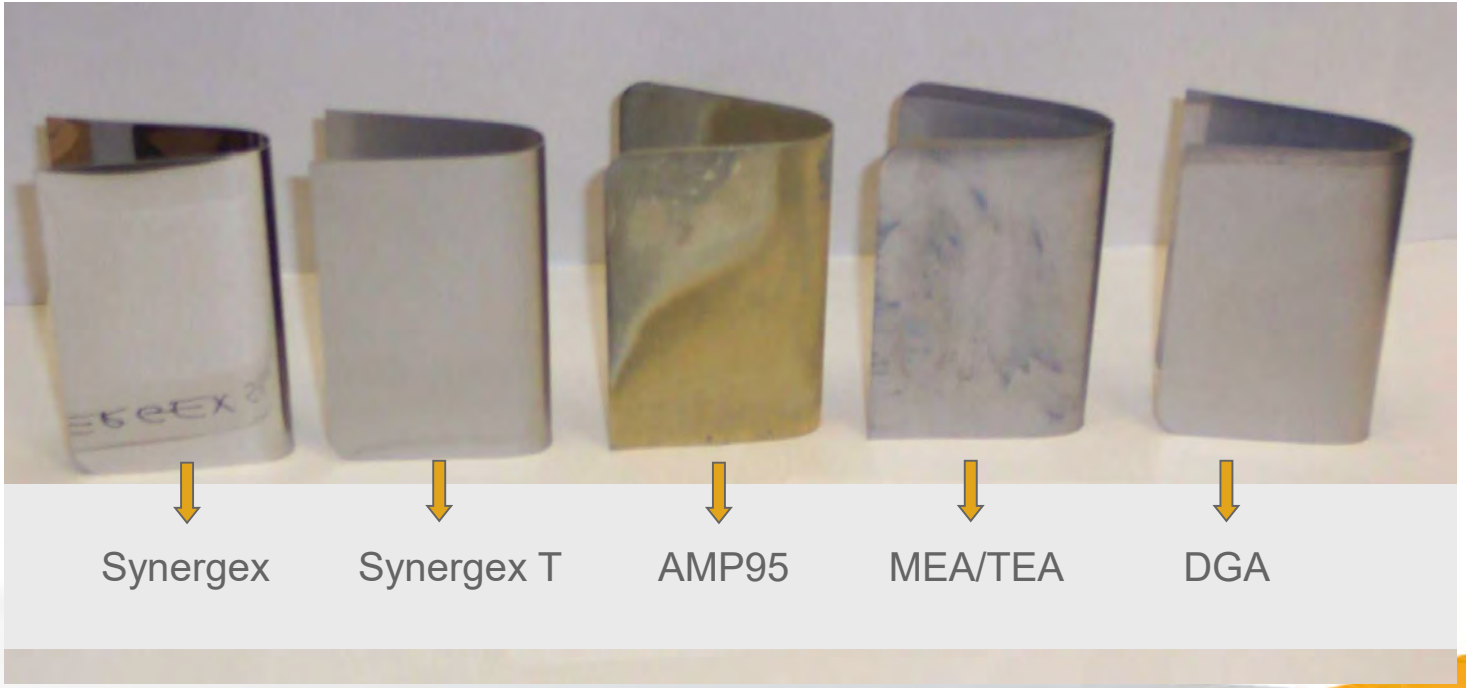


Corrosion rates of steel by polarization resistance



Visual appearance of immersed steel after 1 week

(0.3 M octanoic acid, 0.2 M amine, pH to 8.5)



Synergex LA - newest addition

Synergex LA

As the newest addition to our Synergex product line, Synergex LA serves as an excellent hydrophobic alkanolamine for hydrophobic/hydrophilic amine combinations. **Excellent biostability and easy incorporation into O/W emulsions.**

Amine	NBP °C	% VOC	HLB	Typical use level %	Oil/water partition	pKa
Synergex	200	99	mid-range	4 - 6	water	19
SynergexT	285	< 8	hydophilic	2 - 10	water	9
Synergex LA	230	99	hydrophobic	4 - 8	oil	10

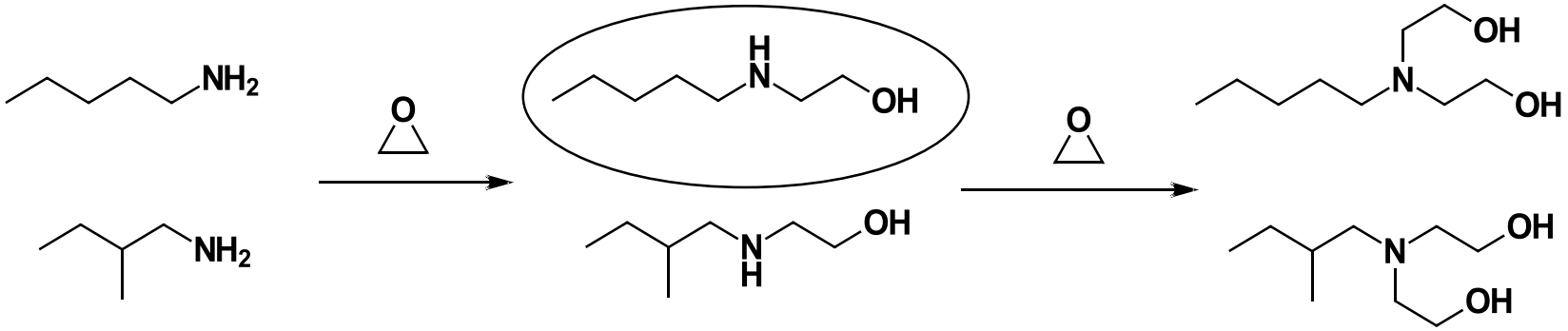
Optimal replacement for DCHA; wise choice for formulators looking for alternatives

NBP = normal boiling point
% VOC per ASTM-E1868
NK = not known
Biostability assessment via integrated MTA (microtiter assay) experiments
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.

In North America, no more hazard of acute toxicity on SDS
US domestic transport only with the change from Class 6.1 to Class 8.
No more problems with shipping

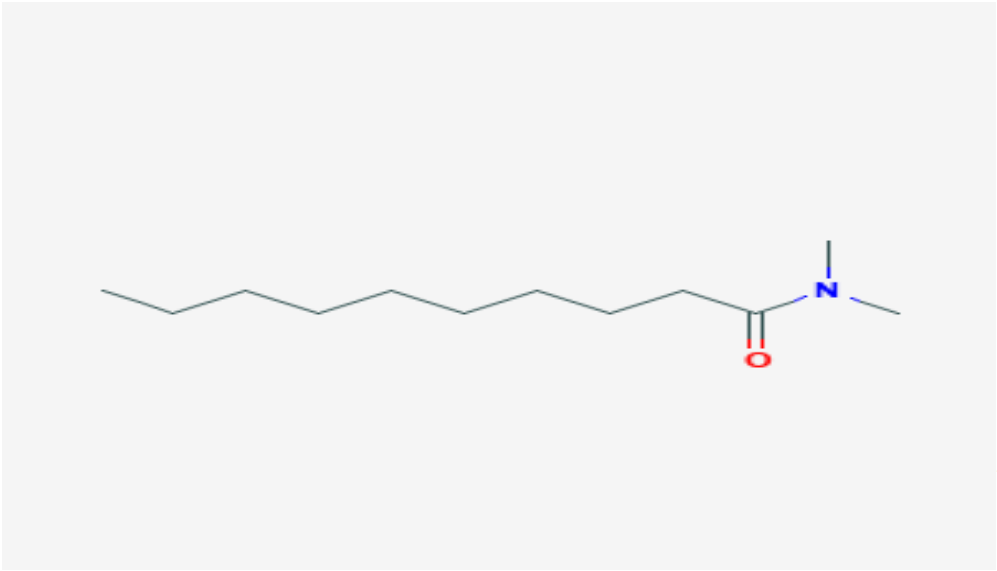
Synergex ideas —
is there something better?

Revisiting an old idea: Ed Bennett's amylaminoethanol work



- Better biostability than current amines but at a higher price
- Secondary amine
- Is there an interest?

Corrosion inhibiting amides C10 and C810 amides in MWF?



- More hydrophobic
- Made from renewable resources like CNO or PKO
- Good wetting, coupling, biosynergy, and corrosion inhibition
- Useful in degreasers
- Commercial products available globally
- REACH compliant

Summary

- Selection of the best amine(s) is the critical first step in formulation.
- Synergex™ alkanolamines are the optimal choice for metalworking fluids; providing biostability, enhanced emulsion stability, low/zero VOC/odor and long life.
- By optimizing your formula, you're ensuring formulation longevity and enhanced product performance.

We're interested in new ideas and want to work with you!

Contact

- To learn more about Synergex, visit www.SynergexAmine.com.
- Eastman contact: Car.Johnson@eastman.com or one of our distributors:

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U.S. East Coast

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