



Green Solvents: The Bottom Line



TBF Environmental Technology Inc.

Develops, manufactures, markets, and distributes **environmentally-friendly solvents** to industrial markets in North America:

- Paints and coatings
- Adhesives
- Printing inks
- Polymers
- Personal care
- General industrial cleaning and degreasing



Green Solvent Issues



*This \$10,000 bottle of Bordeaux is also a powerful solvent.
It entirely dissolved my savings account.*



Green Solvent Issues

- Many alternatives to MEK, Xylene, IPA and Acetone have been developed, but few work well:
- “The opportunity to develop and market solvents with lower ecological and toxicological profiles is excellent ... however, **the perfect solvent is not available**. Tradeoffs have to be made regarding efficiency, cost and environmental impact”
Chemical Insight & Forecasting, Nov 2010.



Green Solvent Issues

- Over 10,000,000 US workers Exposed to toxic solvents on a daily basis.
- Solvent emissions destroy human health and pollute the atmosphere.
- US EPA and State regulators continually impose lower limits on VOCs.
- Methyl Ethyl Ketone (MEK) and Xylene do not meet new regulations.
- Substitute green solvents currently available have serious limitations that limit their efficacy and acceptance.



Hydrocarbon Solvents

A Huge Problem

- Many states are restricting companies annual usage of various hydrocarbon solvents, particularly Xylene and Toluene.
- Companies are trying to scale back usage of solvents and are looking for effective alternatives due to serious legal, health and environmental concerns.
- “Green” solvent alternatives are proving problematic.



Regulations Increasing

- EPA and State regulators, especially California, Texas, Massachusetts are continually imposing lower limits on VOCs of various products.
- Most “Biomass” produced solvents do not meet new regulations, and are shown to have serious environmental problems.
- Carbon footprint, emission byproducts and VOC issues are primary concerns in “biomass” based solvents.



New Regulations

California Air Resources Board (CARB)

Maximum Incremental Reactivity (MIR):

- Volatile Organic Compounds (VOCs) are not the only measurement of the impacts on air quality.
- CARB developed and has initiated the use of the Maximum Incremental Reactivity (MIR) value to quantify the propensity of a chemical compound to react in the atmosphere to form ground-level ozone.



New Regulations

California Air Resources Board (CARB)

Maximum Incremental Reactivity (MIR):

- MIR is being adopted as a replacement for Low Vapour Pressure as more flexible standard in determining suitability of a solvent as "VOC-exempt" or "low VOC".
- Focus on eliminating high-MIR compounds which will have the greatest impact in lowering ambient VOC levels.



New Regulations

California Air Resources Board (CARB)

- Any product that meets the definition of an aerosol coating is regulated.
- Product could default to the lowest general-purpose coatings category limit if not properly labelled.
- General Coatings Maximum Incremental Reactivity (MIR) limits lowered. Effective date 01/01/2017.
- New categories and New MIR limits for some categories called Specialty Coatings (A) effective date 01/01/2017.



New Regulations

California Air Resources Board (CARB)

More Reporting Requirements

Largest Issue:

- General coating limits will be very challenging to meet. Aerosol coatings producers should review this regulation completely to ensure their products are compliant and categorized properly.
- CARB enforcement to be strict and target incorrectly labelled products.



MIR Data

**Maximum Incremental Reactivity (MIR)
(Contribution to ozone and smog)**

Comparison Values

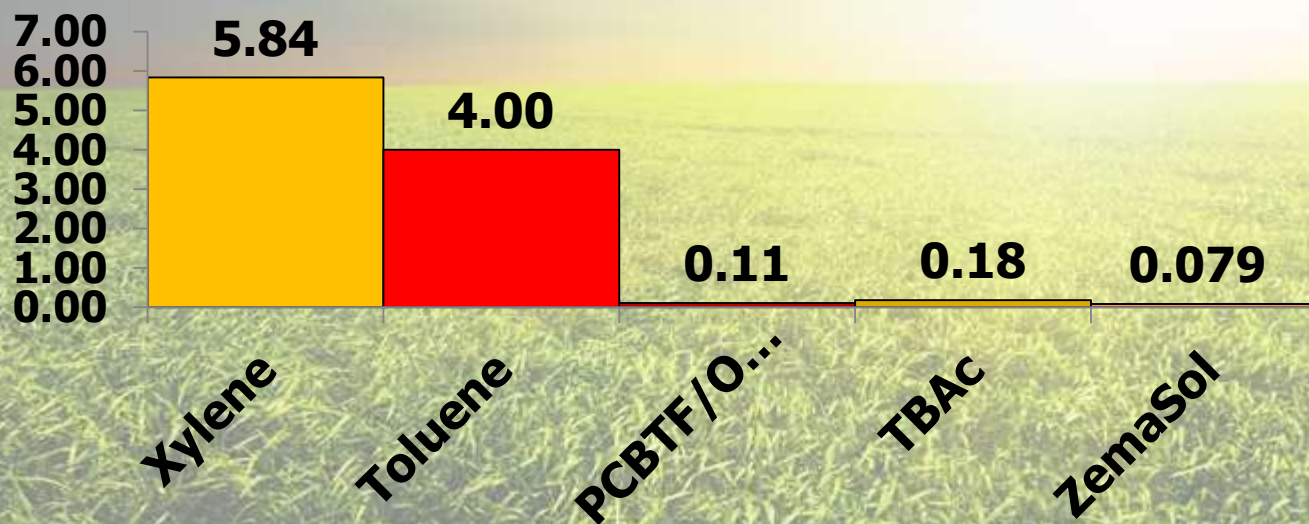
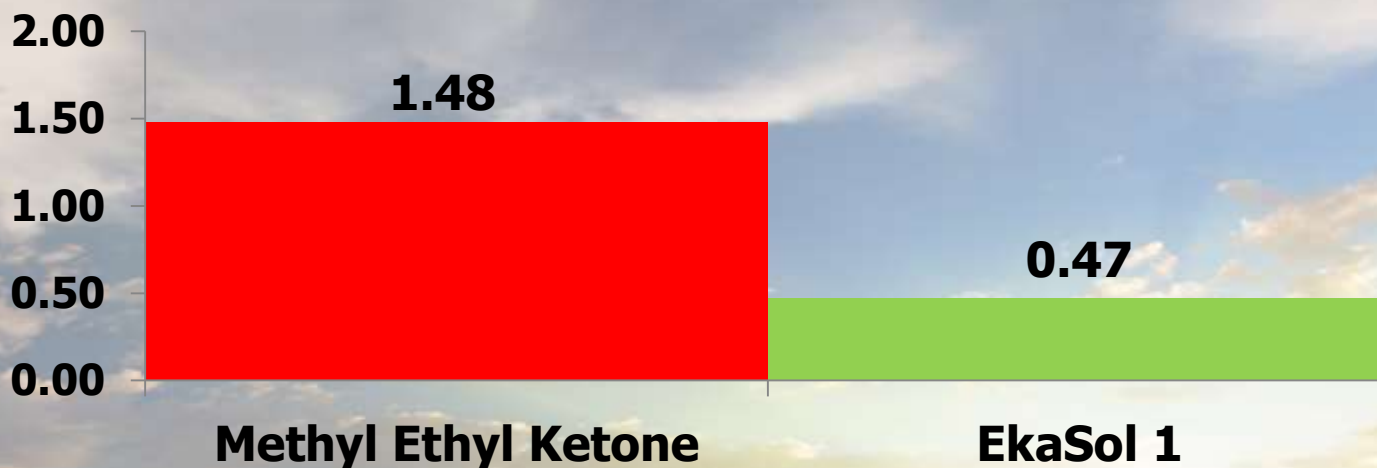
MIR

• Methyl Ethyl Ketone:	1.48
• EkaSol 1	0.49
• Acetone	0.36
• TergoSol	0.065
• Xylene:	5.84
• Toluene:	4.00
• Parachlorobenzotriflouride (PCBTF)	0.11
• Teriary Butyl Acetate (TBAc)	0.18
• ZemaSol:	0.079



MIR Data

Comparison Graph of MIR Values





Green Solvent Alternative

EkaSol 1™

A safe, effective, efficient and cost effective replacement for Methyl Ethyl Ketone (MEK).

- Benzene-free.
- Non-carcinogenic.
- No hazardous air pollutants (HAPs).
- No ozone-depleting or creator chemicals.
- Considered an Ultra-Low VOC Solvent (LVOC) in SCAQMD and CARB, exempt in 49 states.
- EPA 24: EkaSol 2.66 g/l VOC
- Personal Care Council (INCI) Approved



Green Solvent Alternative

EkaSol 1™

- EkaSol 1 can be used in:
- paints and coating formulations and cleaning
- paint and varnish removers
- ink and marker formulations and cleaning
- adhesive formulation and cleaning
- adhesive removers
- gelcoat formulation and cleaning
- fiberglass manufacturing

- EkaSol 1 can be used in or as:
- surface preparation and precision cleaner
- general purpose surface wipe cleaner
- general and heavy duty degreaser
- laboratory and equipment wipe solvent
- brake and contact cleaner
- paint gun and paint line cleaner
- lubricating greases and oils
- automotive chemicals and cleaners
- undercoat formulation and cleaning
- waterproofing compounds
- household dyes and tints
- laundry starches and shoe polishes
- nail polish removers
- hard surface cleaners



Green Solvent Alternative

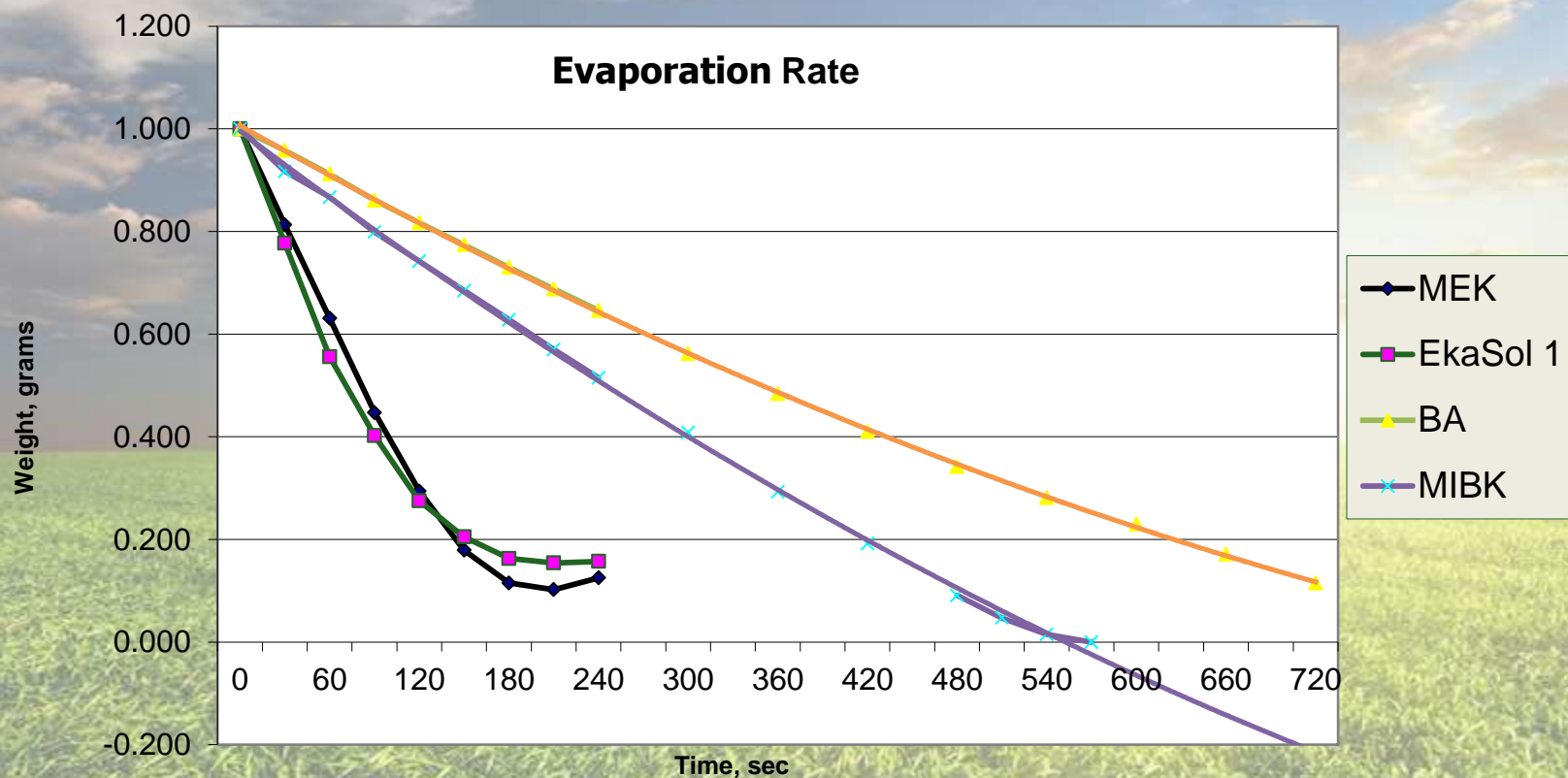
EkaSol 1™

Physical/Chemical Characteristics	EkaSol 1™	Methyl Ethyl Ketone	Methyl Acetate	DiMethyl Carbonate
Density (@25 °C)	0.97	0.804	0.932	8.9
Boiling Point (°C)	75.31	79.6	58	90
Evaporation Rate (n-BuAc=1)	3.62	3.80	6.0	3.2
Flash Point (°C)	9.0	-9.0	-13	17.2
Vapour pressure @20 °C (mm Hg)	125	74	165	42
Freezing Point (°C)	-71.54	-86.7	-98	4
Solvency (Kb Value)	79.1	na	na	64
Maximum Incremental Reactivity (MIR)	0.47	1.48	0.06	0.06
Hansen Solubility Parameters (MPA)				
δd (dispersion)	7.87	7.8	15	15.5
δP (polarity)	3.72	4.4	3.5	3.9
δH (hydrogen bonding)	3.59	2.5	3.7	9.7



Green Solvent Alternative

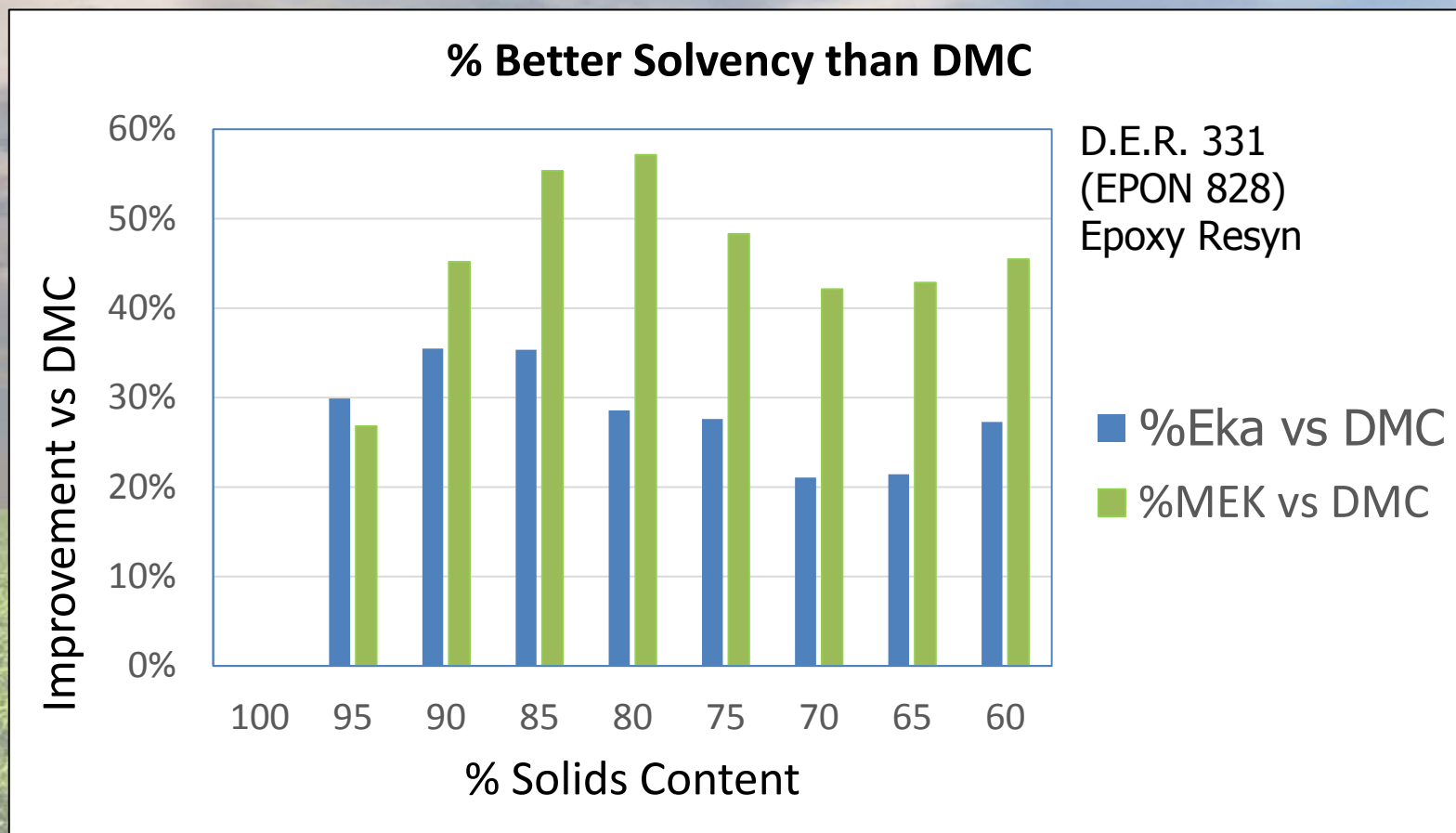
EkaSol 1™





Green Solvent Alternative

EkaSol 1™





Green Solvent Alternative

EkaSol 1™

- EkaSol 1 has a lower, milder odour compared to MEK.
- EkaSol 1 has a similar evaporation rate to MEK.
- EkaSol 1 has a measured ER of 3.62. This is close to the published MEK ER 4.0.
- EkaSol 1 has slightly less solvent power than MEK in the above epoxy formula. This may vary dependent upon formulation and other factors.



Green Solvent Alternative

EkaSol 1™

EkaSol 1 is much less Toxic than MEK:

	MEK	EkaSol 1™
• Oral Toxicity:		
LD ₅₀ Rat (mg/kg)	2700	>5500
• Dermal Toxicity:		
LD ₅₀ Rabbit (mg/kg)	6480	>20,000
• Long Term Organ Damage:		
	Yes	No
• Central Nervous System Damage		
	Yes	No



Green Solvent Alternative

TergoSol™

A safe, effective, efficient and cost effective replacement for Acetone.

- Benzene-free.
- Non-carcinogenic.
- No hazardous air pollutants (HAPs).
- No ozone-depleting or creator chemicals.
- Considered an Ultra-Low VOC Solvent (LVOC) in SCAQMD and CARB, exempt in 49 states.
- VOC (EPA 24): 2.82 g/l VOC.
- Boeing Spec 5750 - approved for Aerospace Cleaning.



Green Solvent Alternative

TergoSol™

TergoSol can be used in or as:

- **paint formulations and cleaning**
- **ink and marker formulations and cleaning**
- **adhesive formulations and cleaning**
- **hard surface cleaning**
- **lubricating greases and oils**
- **aerospace cleaning applications**
- **automotive chemicals**
- **nail polish and polish remover**
- **TergoSol can also be used as a:**
- **surface preparation and precision cleaner**
- **general purpose surface wipe cleaner**
- **general and heavy duty degreasing**
- **laboratory and equipment wipe solvent**



BTEX Solvents are Toxic

Benzene, Toluene, Ethyl Benzene, Xylene (BTEX)

- Proven to be serious risks to human health: asthma, lower birth weights, hearing loss and permanent damage to Central Nervous System.
- BTEX solvents are major emitters of Volatile Organic Compounds (VOCs) which create smog.
- BTEX solvents pollute soil and groundwater.



Green Solvent Alternative

ZemaSol™

A safe, efficient, effective and cost-effective replacement for Toluene and Xylene, Parachlorobenzotrifluoride (PCBTF) and Tertiary Butyl Acetate (TBAc).

ZemaSol:

- is formulated to be benzene-free.
- is non-carcinogenic.
- does not contain hazardous air pollutants.
- environmentally hazardous ingredients.
- Ozone depleters or creators.
- is VOC-exempt and NPRI-exempt (SCAQMD Ultra low VOC 1.13 g/l).



Green Solvent Alternative

ZemaSol™

ZemaSol is designed for a variety of uses and purposes.

ZemaSol can be used as a diluent for:

- **paints**
- **coatings**
- **adhesives**
- **resins**
- **silicones**
- **sealants**

ZemaSol can also be used as a chemical diluent for:

- **printing ink**
- **adhesives**
- **lacquers**
- **plastics**
- **perfumes**
- **pesticides**
- **leather tanning**
- **parrafin wax**



Green Solvent Alternative

ZemaSol™

Physicochemical Property	ZemaSol™	PCBTF	TBAC	Xylene	Toluene
Specific Gravity (@ 25 °C)	1.00	1.34	0.87	0.87	0.86
Flashpoint (Tag Closed Cup (TCC) °C)	4.00	42.8	16.7	17	16
Boiling Point °C	70-90	139	98	110.6-144	135
Appearance	Clear liquid	Clear liquid	Clear liquid	Clear liquid	Clear liquid
Viscosity @ 20 °C (CentiPoise Cp)	0.44	0.79	0.70	0.34	0.59
δ (Hansen solubility parameter) Hildebrand = 1 cal ^{1/2} cm ^{-3/2}	9.18	9.15	7.77	9.36	8.88
δD (Dispersion) cal ^{1/2} cm ^{-3/2}	7.76	8.8	7	9.2	8.8
δP (Polar) cal ^{1/2} cm ^{-3/2}	3.42	2.9	1.7	1.3	0.68
δH (Hydrogen bonding) cal ^{1/2} cm ^{-3/2}	3.46	1.9	2.9	1.15	0.98
Surface tension (dynes/cm at 20 °C)	25.03	25	22.4	25.32-28.27	27.73
Evaporation rate (n-butyl acetate = 1)	5.14	0.9	2.8	0.9	1.9
MIR (gO ₃ /g VOC)	0.076	0.11	0.20	4.25 – 10.71	3.97
Solvency (Kb value)	90.30	64	114	98	105



Green Solvent Alternative

ZemaSol™

Experimental Data:

- ZemaSol™ is a clear liquid with a mild fruity, non-offensive odour.
- ZemaSol has a specific gravity of 1.004.
- ZemaSol evaporated faster than Xylene by a factor of 1.63-1.65.
- ZemaSol has a pronounced “tail” at end.
- Aids in flow and levelling and helps prevent unwanted dry spray.



Green Solvent Alternative

ZemaSol™

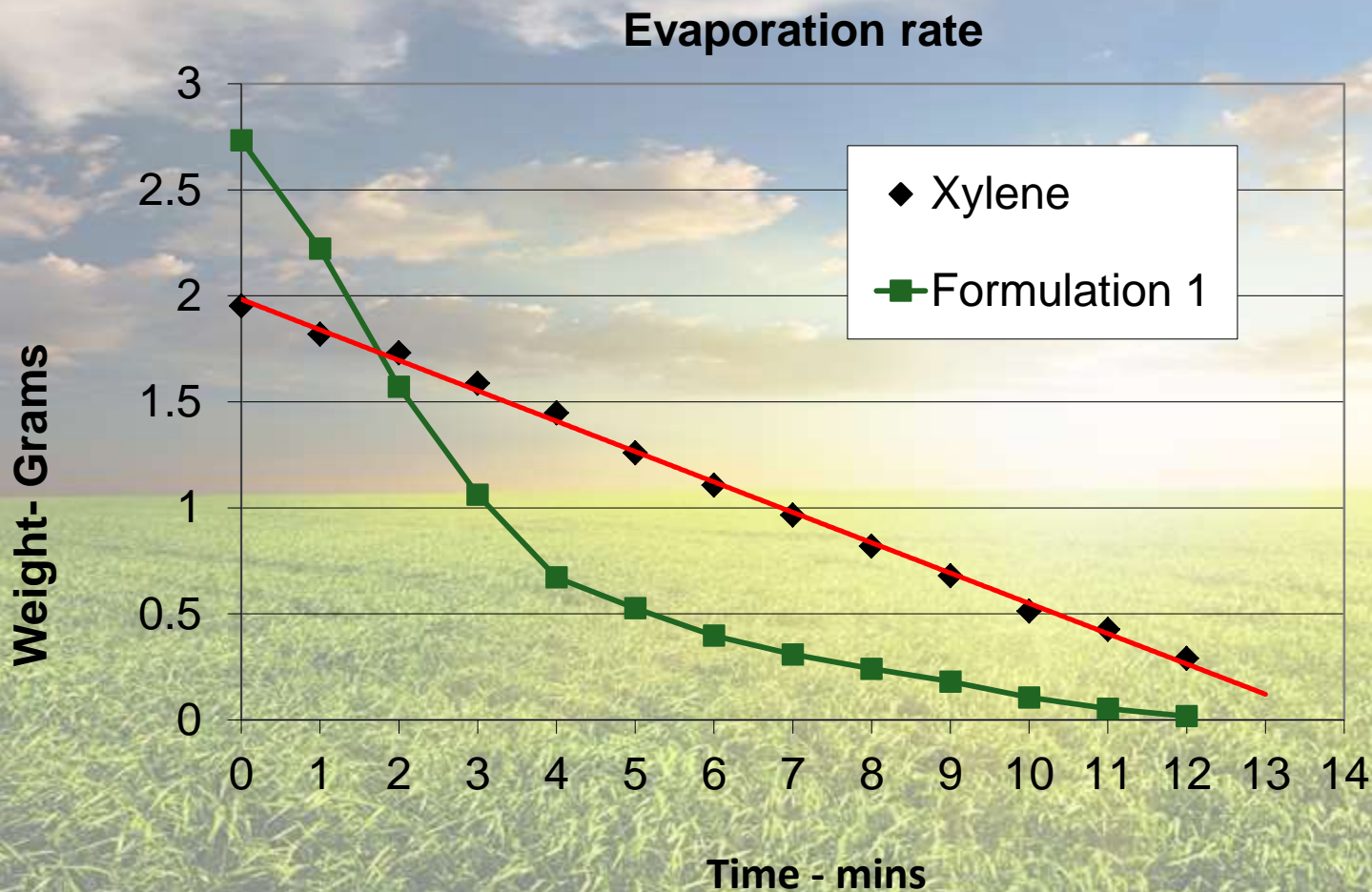
ZemaSol and Xylene
Clear Tint Base
Chain Stop Alkyd Formulation

Properties	Control Formula	Formula With ZemaSol
Weight Solids, %	33.31	31.97
Volume Solids%	24.82	24.82
Specific Gravity	0.942	0.982
Viscosity, KU	95.2	58.1
Gloss 20° / 60°	86.0 / 96.6	82.5 / 95.8
VOC g/l minus exempt solvent	628	543
Dust Free, mins		
Tack Free, mins	20	15
Hard Dry, mins	30	20



Green Solvent Alternative

ZemaSol™



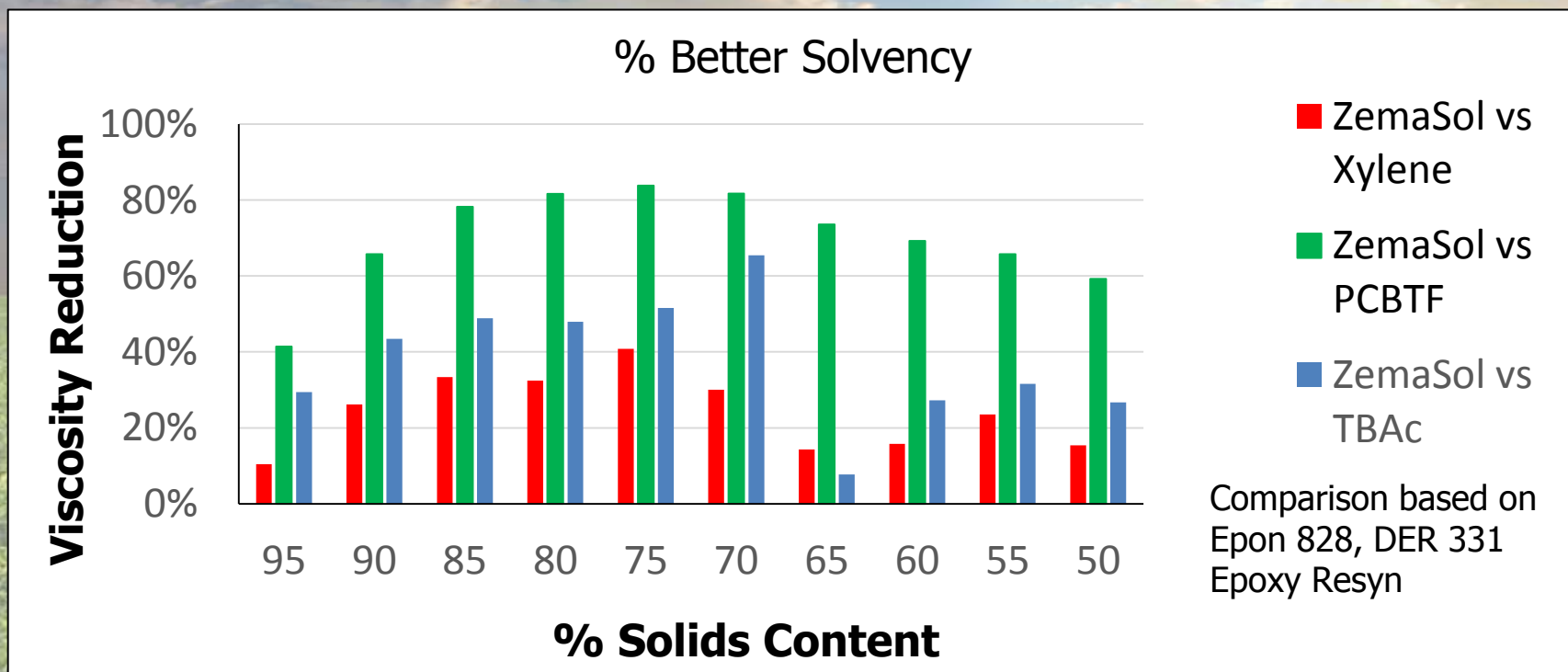


Green Solvent Alternative

ZemaSol™

Solvency Comparisons

- ZemaSol has better solvency and solubility than Xylene and its conventional substitutes





Green Solvent Alternative

ZemaSol™

ZemaSol is much less Toxic than Xylene:

Xylene

ZemaSol

- Oral Toxicity:

LD50 Rat mg/kg

2119

>6000

- Dermal Toxicity:

1700

>5000

- Long Term Organ Damage:

Yes

No

- Central Nervous System Damage

Yes

No



Green Solvent Alternative

ZemaSol™

Conclusions

- Improved odour.
- Improved solubility.
- Improved Viscosity Control .
- Reduced overall VOC content.
- No negative effect on:
 - (i) Gloss
 - (ii) Flow
 - (iii) Tack
 - (iv) Film appearance
- Improved dry time



Summary

Issues:

- Greenwashing
- Toxicity
- Long Term chronic exposure
- Problems with alternative “green” solvents

Regulations:

- New regulations in Massachusetts and CARB coming
- MIR Value of Solvents becoming increasingly important
- Overall VOC content of finished goods decreasing



Summary

Possible Green Solvent Alternatives

EkaSol 1™ – replacement for MEK

TergoSol™ – replacement for Acetone

ZemaSol™ – replacement for Xylene, Toluene
TBAC, PCBTf

BibaSol™ - replacement for
Methyl n-Amyl Ketone (MAK),
Texanol™



Green Solvent Alternatives

RipaSol

- replaces IsoPropyl Alcohol

AbbaSol

- replaces Styrene monomer

In Development

- **0 VOC** Hexane/Heptane replacement*
- **0 VOC** Mineral Spirits replacement*
- **NMP** (4th quarter 2015)

(*Scheduled release Q1, 2015)



Summary

