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Update on the VOC Exemption of tert-Butyl Acetate (TBAC) and Overview of its Uses in Low-VOC, Solvent-Based Coatings

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Outline

- **Solvent in coatings – why they are used**
- **Solvent regulations**
- **Tertiary-butyl acetate as a compliance tool**
 - *TBAc solvent properties*
 - *Coating resin solubility*
 - *Plastics compatibility*
 - *Sample reformulation*
- **Conclusions**

Solvent Use in Coatings

- Resin synthesis
- Coating formulation
- Surface preparation
 - *Parts degreasing*
 - *Hand wipe cleaning*
- Application
 - *Viscosity reduction*
 - *Surface wetting*
 - *Adhesion to substrate*
 - *Film formation*
 - *Properties development*
- Cleanup
 - *Spray gun cleanup*
 - *Paint strippers*



Solvent Regulations Multiply...

- International regulations
 - *Montreal protocol on ozone depleting substances (ODS)*
- National regulations
 - *Control of Volatile Organic Compounds (VOCs)*
 - *Control of Hazardous Air Pollutants (HAPs)*
- State and local regulations
- Continued decrease in allowed VOC and HAP contents

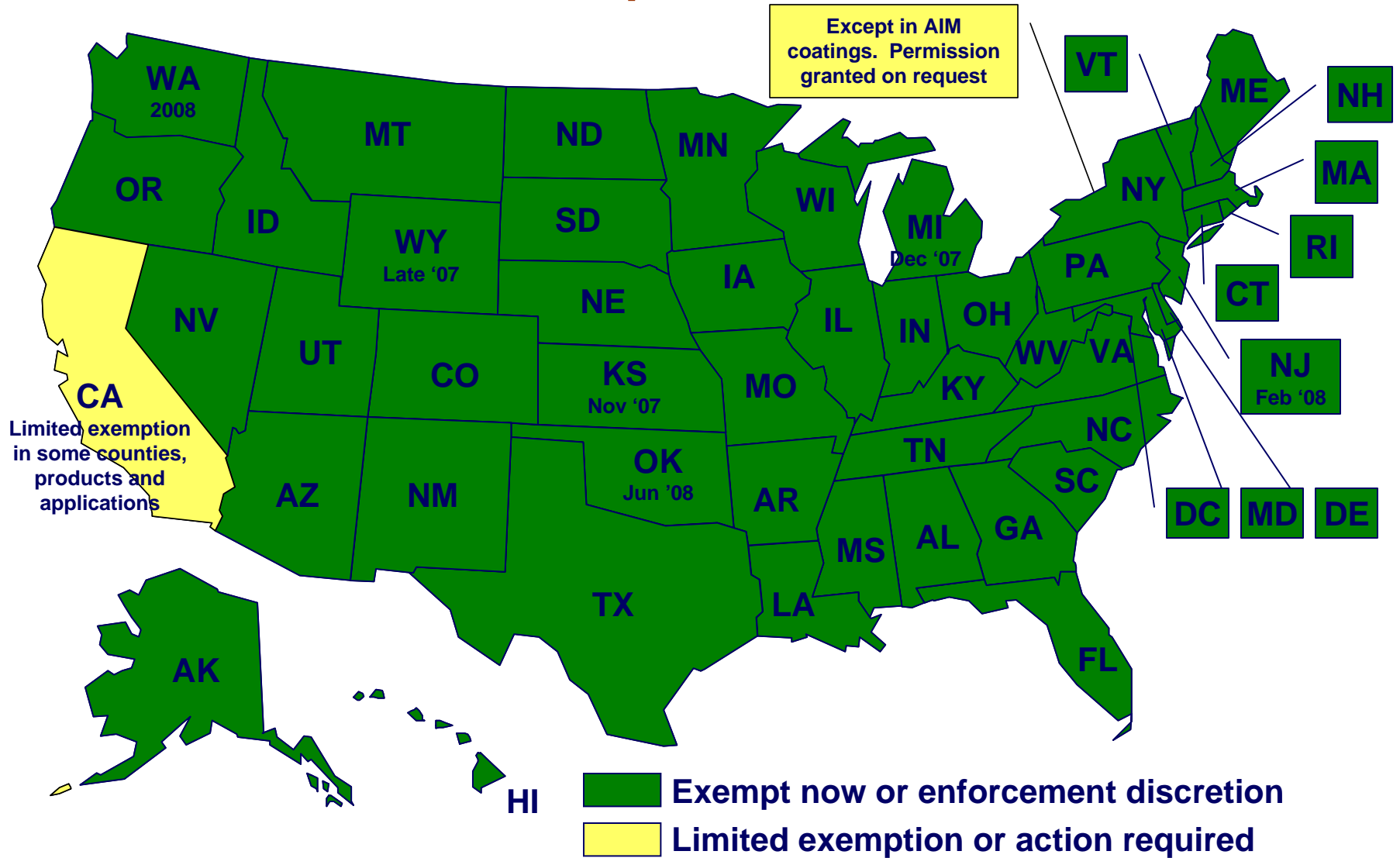
Solvent & Regulatory News

- TBAC added to the EPA list of VOC-exempt solvents on December 29, 2004.
- EPA, OTC, LADCO and CA districts continue to ratchet down VOC & HAP content limits for paints, coatings and cleanup.
- Nation goes to 8-hour ozone standard of 0.08 ppm, increasing the number of ozone non-attainment areas.
- Canada is enacting stringent new VOC limits based on OTC, CARB, and EPA rules.

Low-VOC Technologies Have Limitations

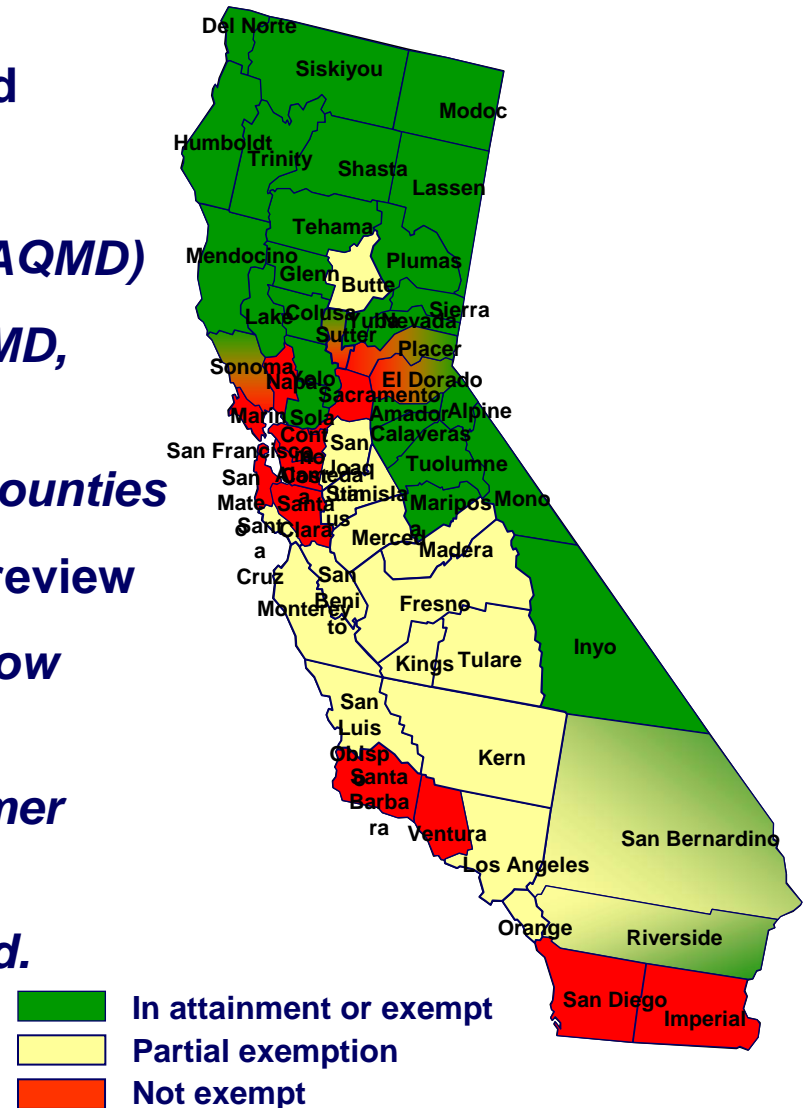
- Water-based
 - + *Low odor, non-flammable, low VOCs & HAPs*
 - *Dry times, freezing, corrosion, energy, equipment, foaming*
- UV-cured & Powder
 - + *Low odor, non-flammable, no VOCs or HAPs, productivity*
 - *Energy, safety, equipment, substrates, performance range, field application, 3D curing, pigmented coatings, cost, training*
- Solvent-based with exempt solvents
 - + *Fast cure, ease of use, performance, cleanup, stable, inexpensive, low VOCs and HAPs*
 - *Odor, flammability, inhalation risk*

TBAC State VOC Exemption Status – October 2007



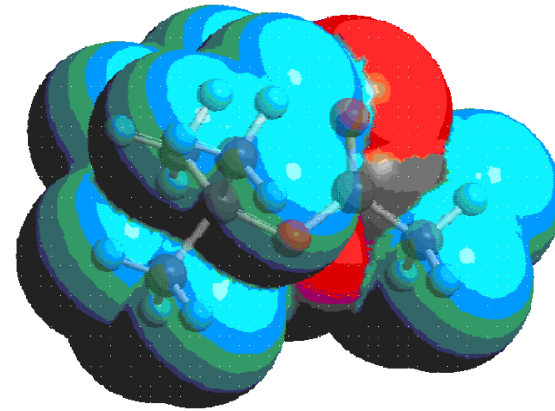
California

- All County and District regulators notified
- TBAC exempt in:
 - *Industrial maintenance coatings (SCAQMD)*
 - *Automotive refinish coatings (SCAQMD, SJVUAPCD)*
 - *Several product categories in other counties*
- CARB and SCAQMD waiting for OEHHA review
 - *New studies confirm that TBAC has low toxicity.*
 - *CARB weighing exemption in consumer products.*
 - *Continued Industry support is needed.*



What is TBAC?

- Tertiary-butyl acetate (CAS 540-88-5)
- An ester solvent
- A substitute for medium to fast-evaporating HAP and VOC solvents
- A compliance tool for:
 - *Cleaners and degreasers*
 - *Solvent-based industrial coatings and aerosols*
 - *Thinning solvents*
 - *Cleaning substrates and equipment*



TBAC Regulatory & Environmental Profile

- **VOC-exempt in most of the US**
- **Non-HAP**
- **SNAP-approved as an alternative to ODC solvents**
- **Not a SARA-313, EPA 17, or AFMC 24 chemical**
- **Not on Prop 65 list**
- **Not a listed or suspected carcinogen or reproductive toxin**
- **Biodegradable**
- **Not an ozone, PM or SOA precursor**
- **Not a global warmer or ozone depleter**
- **Not bioaccumulative or persistent (BCF < 5)**
- **Low mammalian and aquatic toxicity – limited water solubility (<1%)**

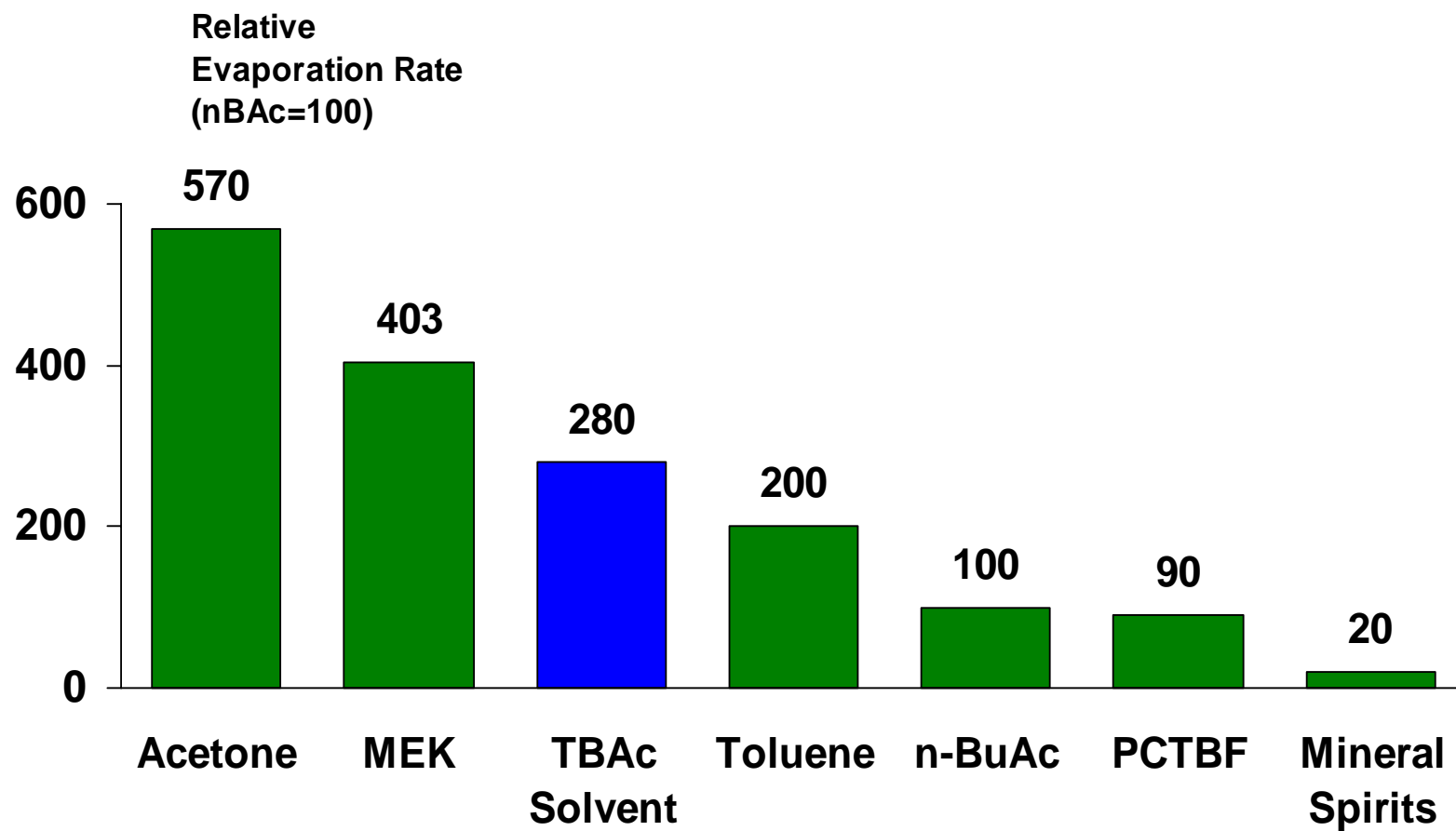
TBAc Solvent Properties

- Broad solvency
- Water insoluble
- Low surface tension
- Low density
- Aprotic solvent
- Recyclable
- Non-corrosive
- Biodegradable
- Cost effective

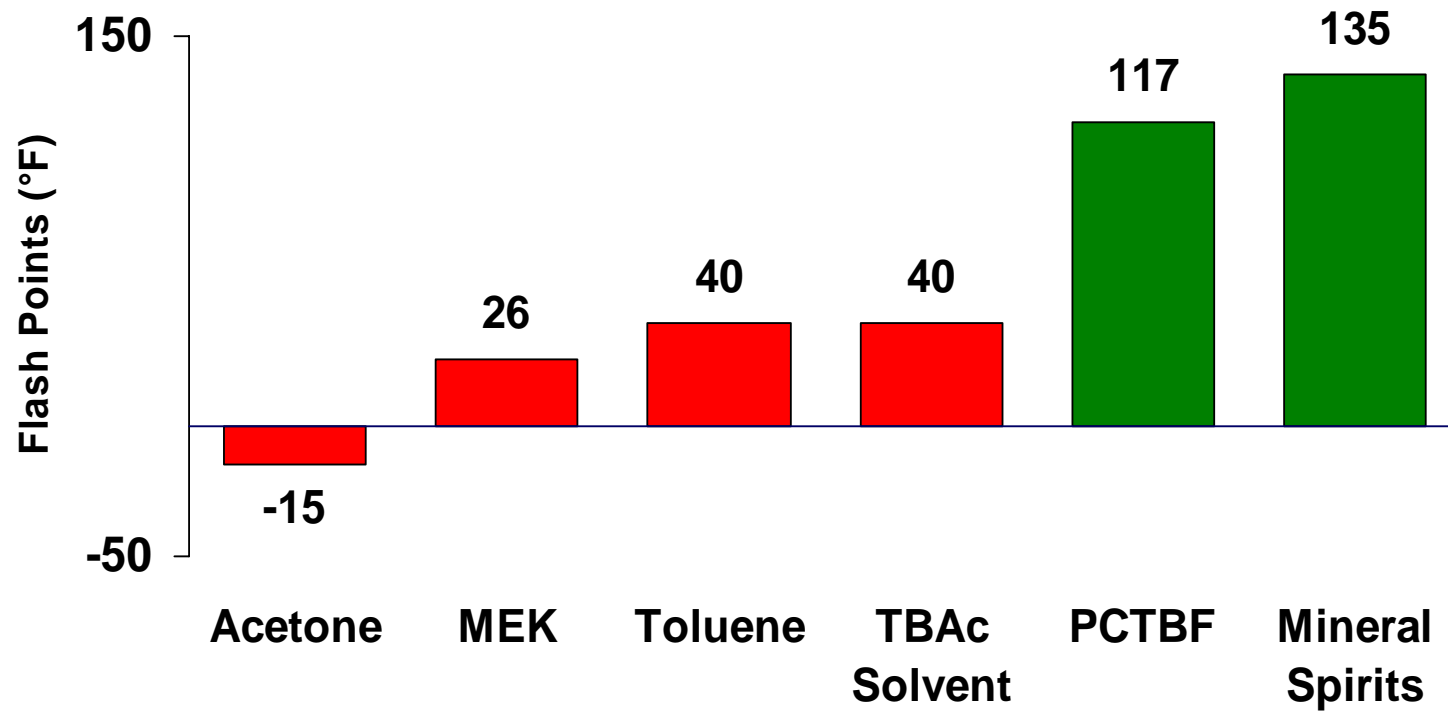
Physical Properties

CAS Number	540-88-5
MW, g/mole	116.16
Water Solubility	<1%
Boiling Point	98°C
Melting Point	-62°C
Evaporation Rate	278 (n-BuAc=100)
Flash Point	40°F
Vapor Pressure (mm Hg)	34 @ 25°C
Density @ 25°C	0.867 g/ml (7.24 lbs/gal)
Surface Tension @ 25°C	22.4 Dynes/cm ²
Kauri-Butanol (KB) value	114
Viscosity (cps @ 25°C):	<1
Hansen Solubility Parameters, cgs	
	D 6.97
	P 1.66
	H 2.91
	Total 7.73
OSHA PEL	200 ppm

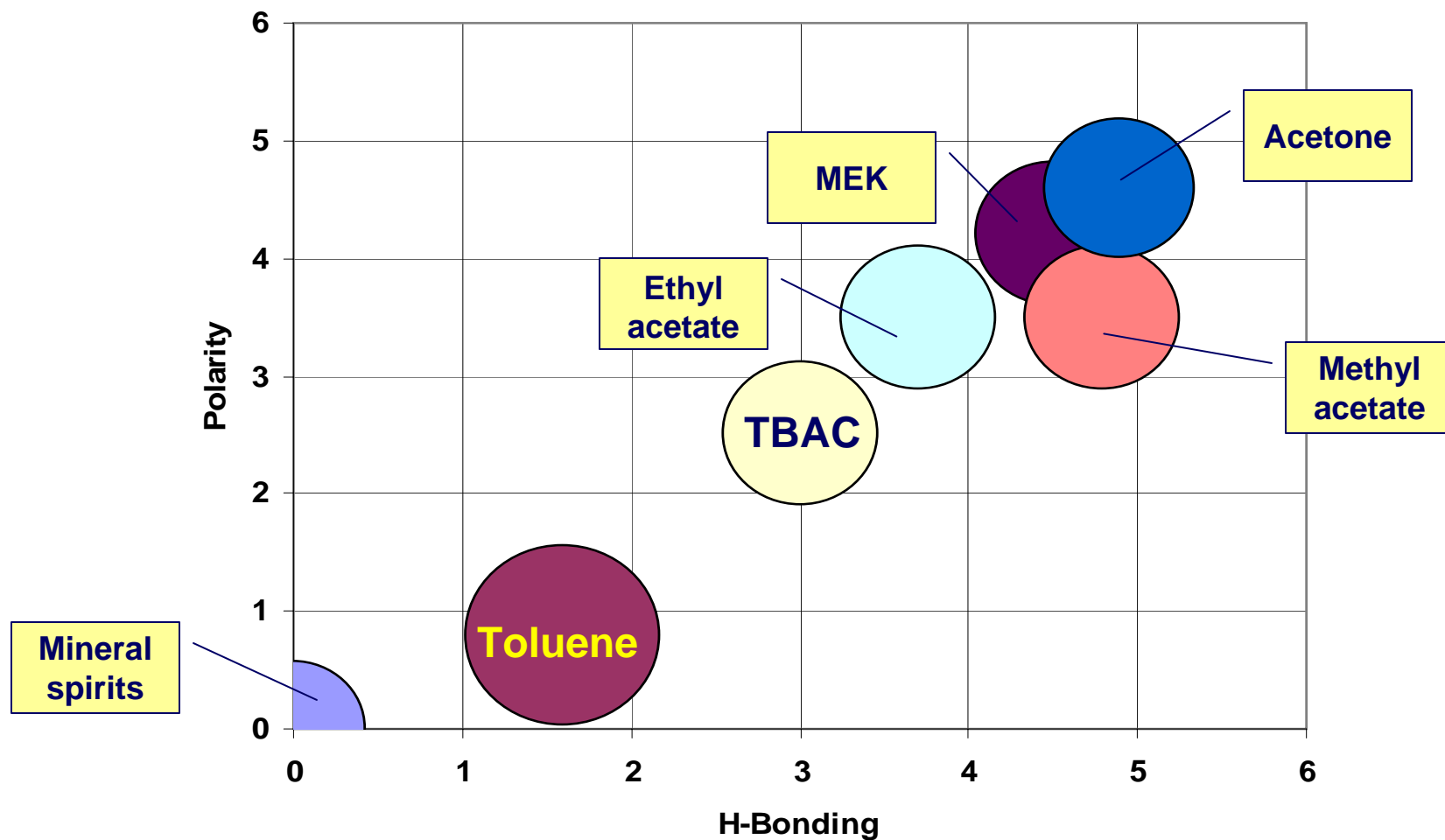
Evaporation Rate Comparison



Flash Point Comparison

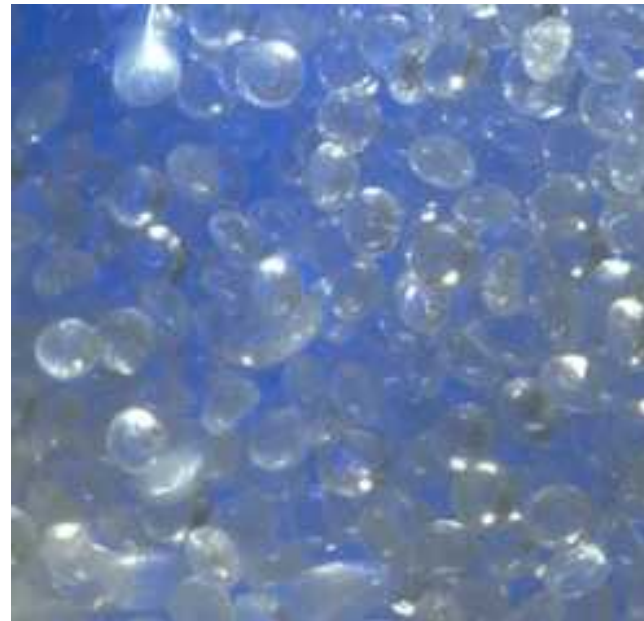


Solubility Parameters of Coating Solvents



Resin Solubility

- Acrylic polyols and thermoplastics
- Alkyds and modified alkyds
- Nitrocellulose
- Urethanes and isocyanates
- Epoxies
- Chlorinated resins
- Styrenated resins



Compatibility with Plastics

- Active solvent for:
 - *Acrylics & styrenated-acrylics*
 - *Styrenics: ABS, SBR, PS*
 - *Unsaturated polymers: PolyBD,*
- Not a solvent for:
 - *PE, PP*
 - *PVC*
 - *Saturated hydrocarbon polymers*
- Less aggressive than ketones and n-BuAc
 - *Reduces “telegraphing” of surface defects*

Wood Lacquer Formulations

Components	Conventional Formulation	TBAc/n-BuAc Formulation	TBAc/PMAc Formulation
RS 1/2 Nitrocellulose	14.3	14.3	14.3
Beckosol 12-035	11.7	11.7	11.7
Diisononyl phthalate	3.0	3.0	3.0
xylene	30.5	0.0	0.0
MEK	10.7	0.0	0.0
n-butyl acetate	22.7	13.9	0.0
n-butanol	7.1	7.1	7.1
PM Acetate	0.0	0.0	13.9
TBAc Solvent	0.0	50.0	50.0
Total lbs	100.0	100.0	100.0
lbs VOC/lb solids*	3.99	1.50	1.50
lbs HAP/lb solids	2.29	0.23	0.23
Viscosity, cps	146	185	102
Dry Time, min	20	10	10
20 degree gloss	42	47	49
60 degree gloss	86	87	89
Whiteness index	65	67	67
Yellowness index	6.0	5.4	5.4

Nitrocellulose resin from Hercules' Aqualon Division.
 Beckosol® is a registered trademark of Reichhold Chemical.



2K Urethane Clearcoat Formulations

Components	Conventional	TBAC-Based	Conventional High-solids	TBAC-Based
G-Cure 105 P70	100.0	100.0	50.0	50.0
JONCRYL 920	0.0	0.0	50.0	50.0
T-12 (1% in toluene)	1.9	1.9	0.3	0.3
FC 430 (10% in toluene)	0.3	0.3	0.3	0.3
HDI Trimer	28.3	28.3	33.9	25.4
IPDI Trimer	0.0	0.0	0.0	15.6
MAK	25.0	25.0	24.0	24.0
n-Butyl acetate	25.0	0.0	24.0	0.0
TBAc Solvent	0.0	25.0	0.0	24.0
Total lbs	205.5	205.5	206.5	213.6
% solids	46%	46%	51%	51%
lbs VOC/gal*	4.40	3.28	3.96	2.86

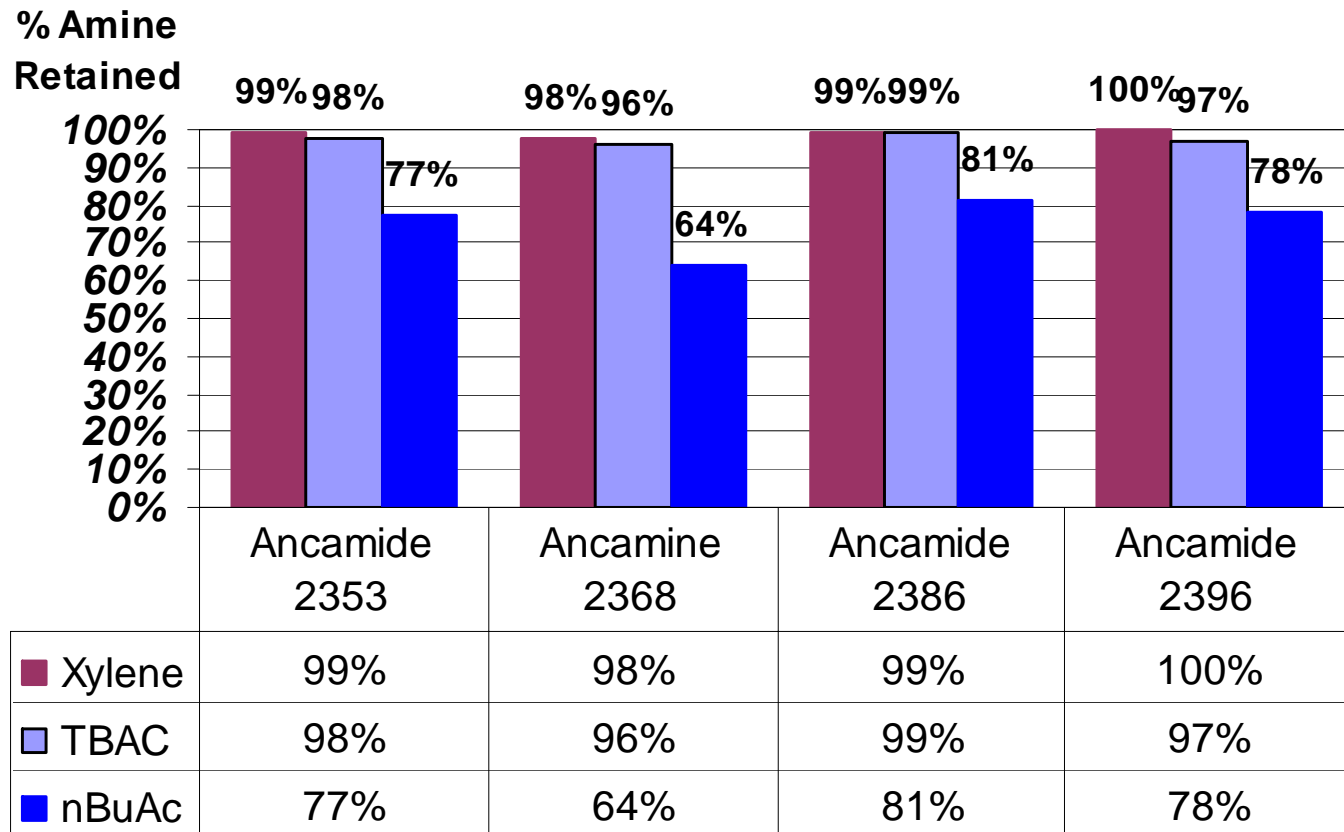
G-Cure® is a registered trademark of the Cognis Corporation
 JONCRYL® is a registered trademark of Johnson Polymers

2K Urethane Clearcoat Properties

Properties	Conventional	TBAC-Based	High-solids	TBAC-Based
lbs VOC/gal*	4.40	3.28	3.96	2.86
Viscosity, sec #2 Zahn	21.2	21.1	20.9	20.8
Dry Time, hours	3.2	3.5	7	4
20 degree gloss	88	88	90	90
60 degree gloss	95	95	95	95
DOI	90	90	90	90
Reverse Impact, lbs	160	160	160	160
Direct Impact, lbs	160	160	160	160
Cross hatch adhesion, %	100%	100%	100%	100%
10% acid resistance (30 min)	pass	pass	pass	pass
100 MEK double rubs	pass	pass	pass	pass

- Significant VOC reductions possible*
- No change in performance

Epoxy Amine Curative Stability in TBAC



- Xylene and TBAC show similar stability

Ancamide and Ancamine are trademarks of Air Products.

Sample 2K Epoxy Reformulation

	Xylene Formulation	TBAC Formulation
Part A		
Epon 1001X75	301	301
Pigment & fillers	260	260
Beetle 216-8	12	12
Xylene	221	

Aromatic 100		30
ARCOSOLV PM		76
TBAc Solvent		115
MAK		15

Non-HAP Solvents

Part B		
Epicure 3115	131	131
Xylene	70	

Aromatic 100		15
TBAc Solvent		55

Non-HAP Solvents

Formulation constants

Volume Ratio A/B	75/25	75/25
Wt % Solids mixed	62	62

Conclusions

- VOC regulations spreading & getting tougher
- TBAC exemption almost complete in US, Canada
- Reformulating with exempt solvents can:
 - *Maintain product performance.*
 - *Reduce product cost, environmental impact, and hazards.*
 - *Boost sales.*
- TBAC is VOC- and HAP-compliance tool for:
 - *Lacquers and enamels*
 - *Two and one-component systems*
 - *www.tbac.com*

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