UNITED SOYBEAN BOARD

SOYNEWUSES.ORG

Reduce the Carbon Footprint of Paints and Coatings with Soy

Kris Weigal

OMNI TECH
STRATEGIC SUSTAINABLE SOLUTIONS

USE SOY FOR THAT

USSOY

OMNI TECH

Experienced renewable chemistry consultants with expertise in

- Market research and analysis
- IP landscape
- Competitive analysis
- Product commercialization
- Technology assessment
- Strategic planning
- Life cycle analysis
- Technoeconomic analysis
- Regulatory compliance

UNITED SOYBEAN BOARD™

Builds demand to ensure strong, profitable future for U.S. soybean farmers

- Represents the half-million U.S. soybean producers in 30+ states
- Promotes sustainability of U.S. Soy farming
- Funds product development and commercialization
- Checkoff contributions of 0.5% of the net market price per bushel sold
- The USB approved $191.5M for the 2024 fiscal year budget.

U.S. SOY COMMITTED TO SUSTAINABLE FARMING

NET zero 2050

Sustainable Farming Framework

Water Management

Nutrient Management

Conservation Tillage (Strip-Till and No-Till)

Innovations in Plant Breeding and Biotechnology

Forestry, Land Use and Biodiversity

Cover Crops

Buffer Strips, Windbreaks and Agroforestry

Precision Agriculture

Renewable Energy

Infrastructure

U.S. SOY SUSTAINABLE ASSURANCE PROTOCOL (SSAP)

- Third-party audited certification by USDA
- Over 90% participation from U. S. soybean producers
- Focuses on four sustainability directives
- Approved:
  - European Feed Manufacturers' Federation (FEFAC)
  - European Union's Renewable Energy Directive (RED)
  - Global Seafood Alliance Best Aquaculture Practices
  - Tokyo Olympic Procurement Committee
  - Consumer Goods Forum
  - SAI Platform's Farm Sustainability Assessment 3.0 (FSA) – Silver Equivalent

Sustainability by the Numbers

1980-2020

48% *land use efficiency improvement*

60% *irrigation water use efficiency improvement*

46% *energy efficiency improvement*

43% *greenhouse gas emissions efficiency improvement*

34% *per acre soil conservation improvement*

U.S. Soy farmers have increased production of soy by 130% using the same amount of land

2025 Sustainability Goals

measured as acres per bushel

measured as tons per bushel

measured as BTUs per bushel

measured as pounds CO2-equivalent gasses emitted per year

Life Cycle Analysis of U.S. Soy
January 2024

UNITED SOYBEAN BOARD™

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STRATEGIC SUSTAINABLE SOLUTIONS

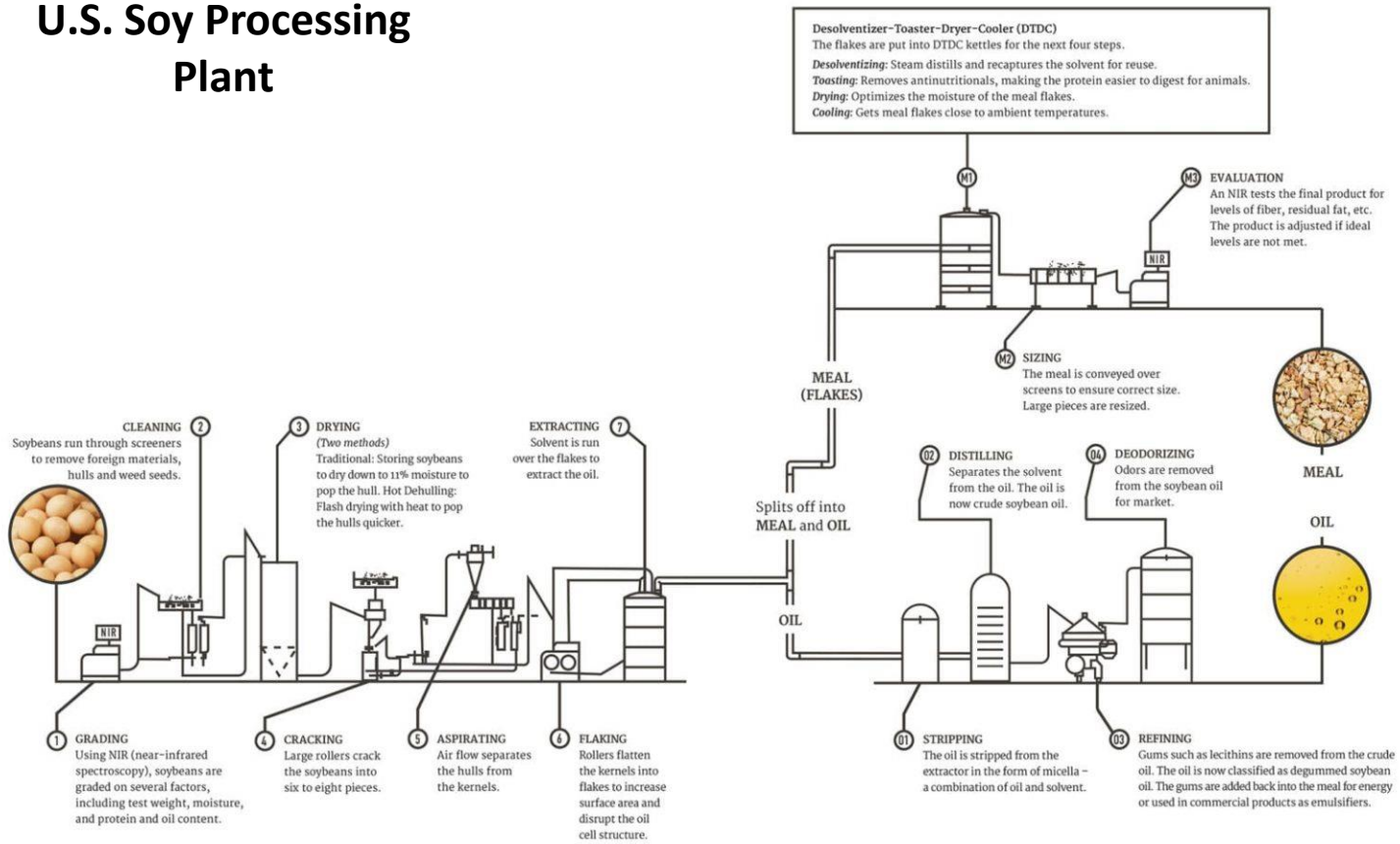
LCA System Boundary

- *Commissioned by the United Soybean Board and the National Oilseed Processors Association by Sustainable Solutions Corp. Jan .2024*
- *Conducted according to ISO 14040 and ISO 14044 International Standards*

Farmers
PLANT > GROW > HARVEST
TRUCK/RAIL

Grain Elevators
STORAGE
TRUCK/RAIL/BARGE

U.S. Soy Processing Plant



Global Warming Potential (GWP) Profile

Since 2015 U.S. soy commodities saw GWP reductions of:

- 19% per kg U.S. soybeans
- 6% per kg U.S. soybean meal
- 22% per kg U.S. crude soy oil
- 8% per kg U.S refined soy oil

Soybean cultivation data from 454 farms across 16 states

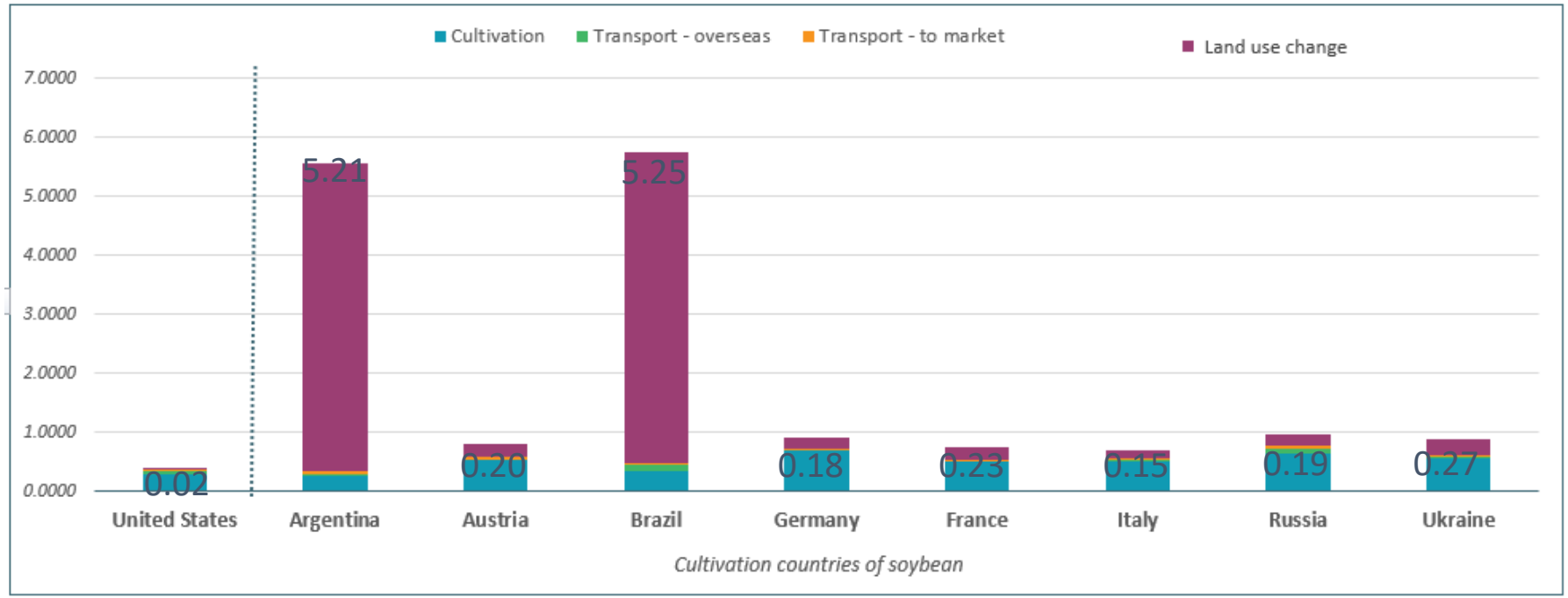
Operations data from 52 soybean processors and 27 soy oil refiners across 18 states

Life Cycle Assessment of U.S. Soybeans, Soybean Meal, and Soy Oil - January 2024
United Soybean Board and the National Oilseed Processors Association

Carbon footprint of US soy

- Carbon footprint (including Land Use Change (LUC) of soybean for European market (kg CO_2-eq/kg soybean)

Not all Soy is the same

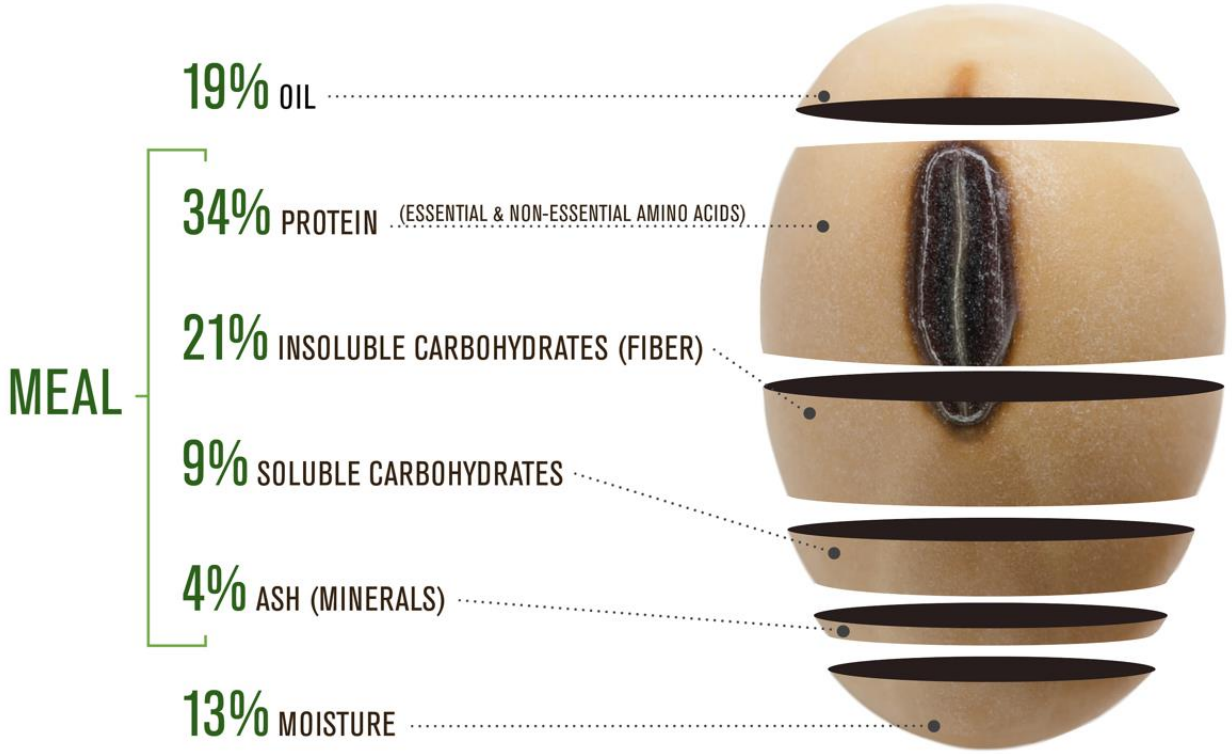


Janjoris Van Diepen, Senior Consultant at Blonk

"U. S. Soy has higher yields, minimal fertilizer use, and efficient machinery, all of which help to minimize U.S. Soy's carbon footprint"

blonk consultants
giving shape to sustainability

SOYBEAN DECONSTRUCTION



27.2 billion pounds of oil available domestically

Source: USDA, USB

WITH U.S. SOY YOU GET BOTH FOOD AND FEEDSTOCKS

FOOD + FUEL AND CHEMICALS

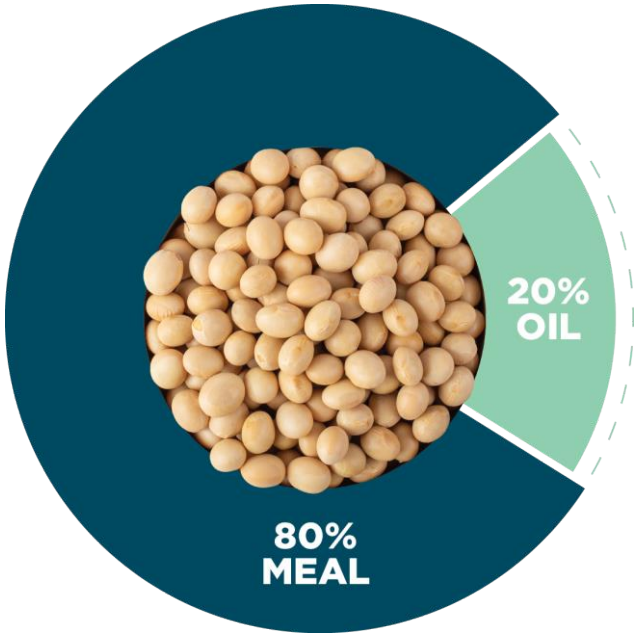
MEAL

95.2%
Animal feed

3.8%
Human consumption

0.50%
Aquaculture

0.43%
Industrial



OIL

43.6%
Human consumption

46.9%
Fuel

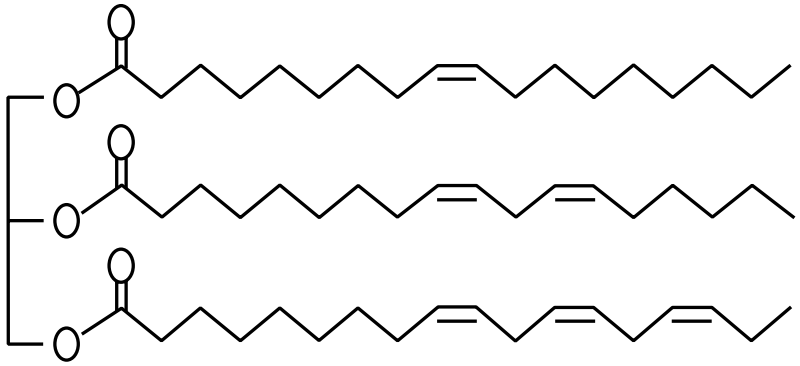
9.5%
Industrial

Source: Market View Database 2022

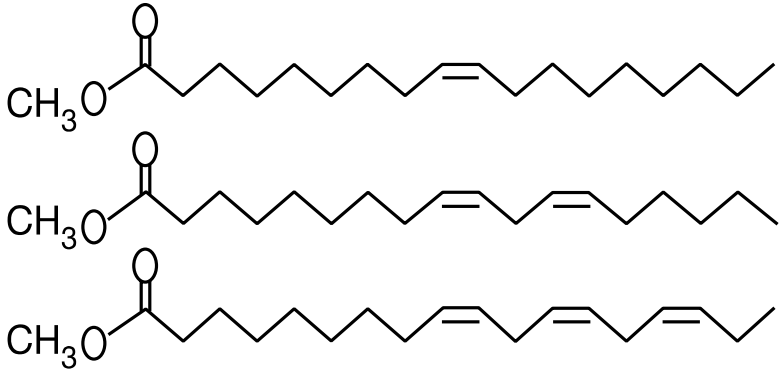
"Soybean meal is the main source of feed protein worldwide"

Dr. Rouf M. Mian, acting research leader of the Soybean Research Unit, USDA – ARS and research geneticist at North Carolina State University

BASIC SOY OIL BUILDING BLOCKS

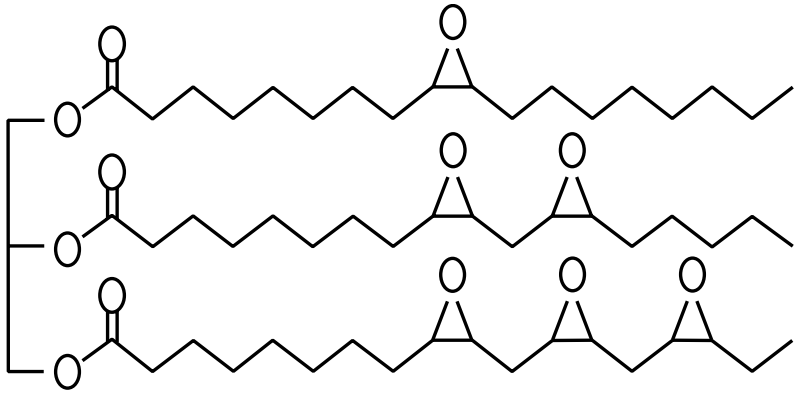


Soybean Oil

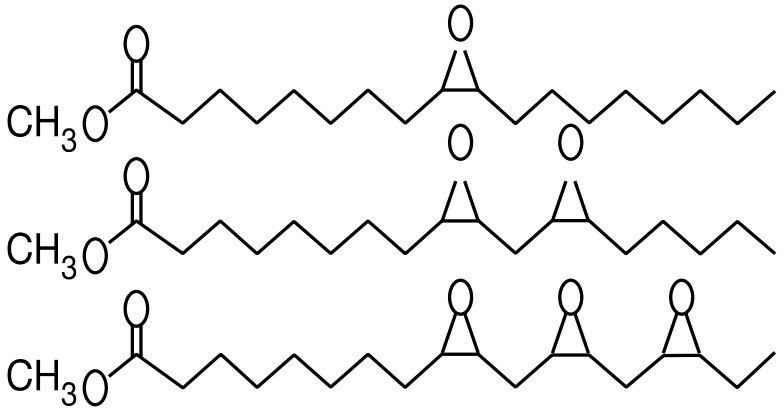


Methyl Soyate

Commercially Available



Epoxidized Soybean Oil



Epoxidized Methyl Soyate

Coatings

Soy in Coatings

Wood Stains

• TRUSTED QUALITY SINCE 1921 •

RUST-OLEUM®

Powder Coatings

BATTELLE

Plasticizers

VALTRIS SPECIALTY CHEMICALS

Cargill®

Dispersants

Lamberti surfactants

EVONIK Leading Beyond Chemistry

Lubrizol

Latex Paints

SHERWIN WILLIAMS

Coalescence

Cargill®

ACS TECHNICAL PRODUCTS

Traffic Paint

REICHHOLD

Aexcel

Solvents

VERTEC BIOSOLVENTS

SOYSOLV® BIOSOLVENTS

Eco Safety Products

Soy Products Guide, United Soybean Board

USB Funded Project
(2321-106-0101 & 2421-106-0101)

STONEBRIDGE
COATINGS LABORATORY, INC.

- Test commercially available soy vs. petro-based coating materials
- Demonstrate effectiveness
  - ✓Real world formulations
  - ✓Key performance properties
  - ✓Optimize soy formulations and compare to commercial coatings
- Share results with coatings industry
  - ✓Raw material suppliers-coating manufactures-end users
- Key materials
  - ✓**Coalescing Solvents for water-based architectural and industrial paints**
  - ✓**Alkyd Dispersions & emulsions for water-based architectural paints**
  - ✓Solvents for alkyd, epoxy & urethane industrial paints
  - ✓Dispersants for solvent-based industrial paints

Part 1. Bio-Based Coalescing Solvents

Coalescents:

B1 – Biomass, 100% BC, 0 VOC

B2 – Soybean oil, 95% BC, 0 VOC

B3 – Soybean oil, 96% BC, 0 VOC

P1 – TMPMB

P2 – Proprietary

P3 -- DPnB / DPM (3:1)

Coatings:

A. Industrial Coatings

- Semi-gloss Direct to Metal (DTM) Paint

B. Architectural Coatings

- Interior/exterior Flat House Paints
- Interior/exterior Semi-Gloss Trim Enamels

Part 1. Bio-Based Coalescing Solvents

(PCI Magazine: April 2024)

Semi-gloss DTM Paint

- ✓ Adhesion
- ✓ Appearance
- ✓ Hardness
- ✓ Flexibility & Impact Resistance
- ✓ + **Corrosion Resistance**
- ✓ UV Resistance

Architectural Flat House Paints

- ✓ Application
- ✓ Appearance
- ✓ Block Resistance
- ✓ Scrub Resistance
- ✓ UV Resistance

Semi-Gloss Trim Enamels

- ✓ Application
- ✓ Appearance
- ✓ Hardness
- ✓ Block Resistance
- ✓ Dirt Pick-Up
- ✓ Scrub Resistance
- ✓ Weather Resistance
- ✓ Package Stability

Paints	Minimum Biobased Content (%)
Industrial Latex DTM	~ 5-6%
Architectural Flats	~ 2-3%
Architectural Semi-Gloss	~ 2-3%
USDA BioPreferred Target - Interior	20%

Part 2. Waterbased Soy-Alkyd Dispersions

Semi-Gloss Industrial DTM Enamels

- Soy Long Oil Alkyds (55-70% Soya Oil)
- Soy Medium Oil Alkyds (40-55% Soya Oil)
- Soy Short Oil Alkyds (<40% Soya Oil)
- Acrylic-modified Alkyds

- Resins 45-55% NV in Water
- Semi-gloss DTM Paints
  - ~50% by Wt./60% by Vol. Resin

WB Soy-Alkyd Dispersions

Semi-Gloss DTM Enamels

Petroleum-Based Commercial Latex Paints	**Bio-renewable WB Soy Alkyd Dispersions**
CB-1 – Commercial DTM Paint Benchmark	AD-1 – Medium oil chain stopped alkyd emulsion 55% NVW
CB-2 – Commercial DTM Paint Benchmark	AD-2 – Acrylic alkyd emulsion 45% NVW
	AD-3 – Short oil alkyd emulsion 50% NVW
	AD-4 – Medium oil alkyd emulsion 53% NVW

WB Soy-Alkyd Dispersions

Semi-Gloss DTM Enamels

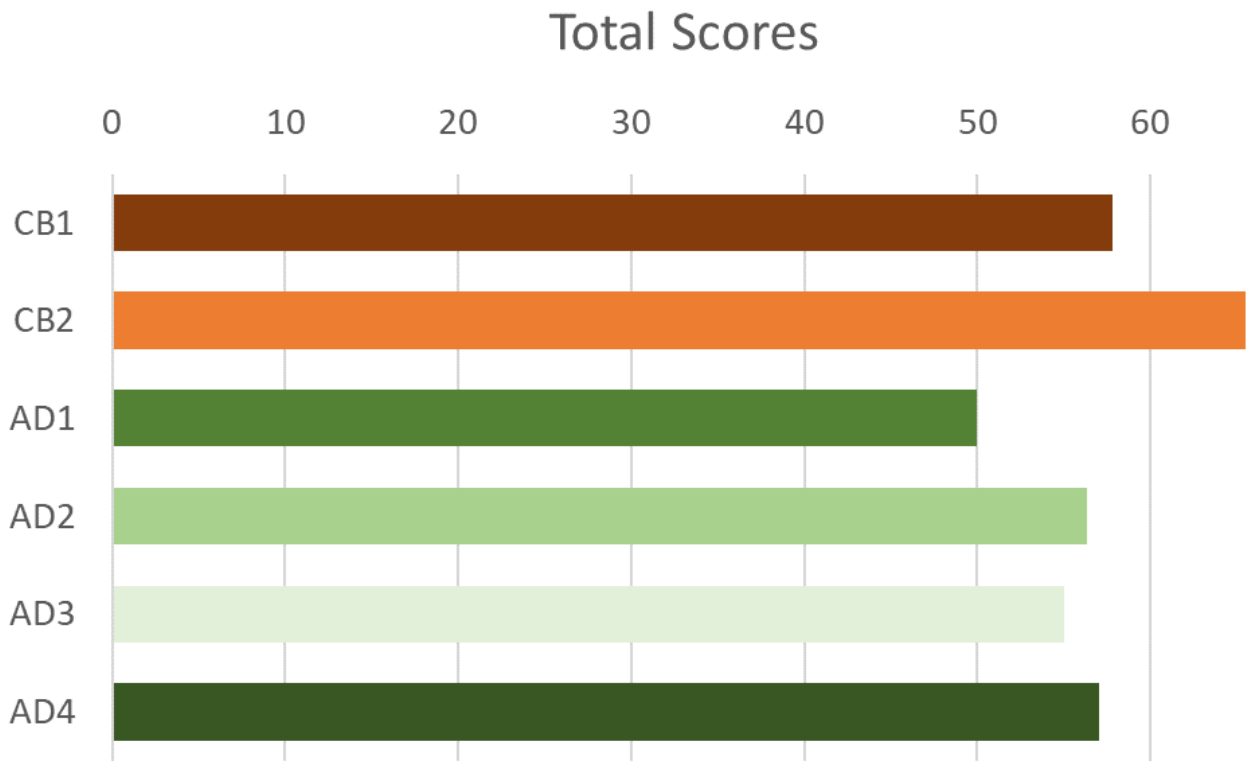
- 4 WB soy-alkyd dispersions
- 2 Commercial DTM paints

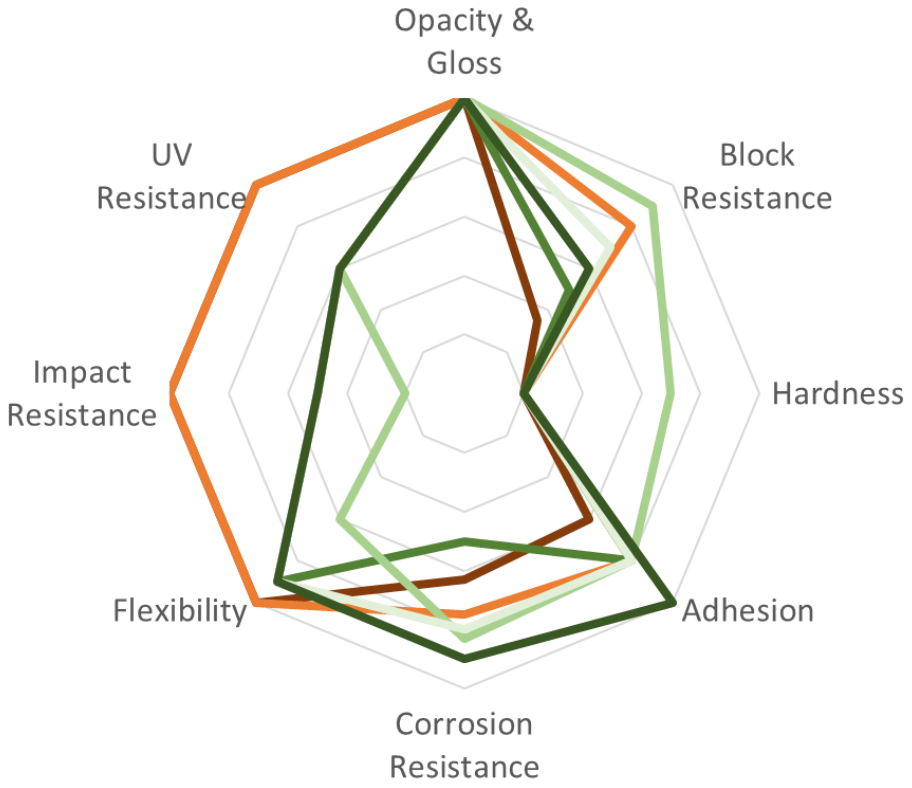
Substrates	CRS & Aluminum
Application	Drawdown
DFT	2.5 & 5 mils
Cure	7 Days Ambient

% PVC	22
% Weight Solids	47
% Volume Solids	34
Density	10.3
VOC (lb/gal)	0

Description	Weight (Lbs)	Volume (Gals)
DI Water	180.48	21.6
Rheology Modifer	5.41	0.81
Dispersant	2.28	0.26
Surfactant	1.63	0.18
Defoamer	2.74	0.33
pH Buffer	1.64	0.21
Titanium Dioxide	187.05	5.60
Corrosion Inhibiting Pigment	45.10	1.64
Soy-alkyd Emulsion	530.69	60.56
pH Buffer	3.48	0.46
DI Water	53.94	6.46
Cobalt-free Drier	4.78	0.55
Defoamer	2.75	0.32
Flash Rust Inhibitor	9.02	0.98
Totals	1031	100

Semi-Gloss DTM Enamels – Optimized vs. Commercial Paints





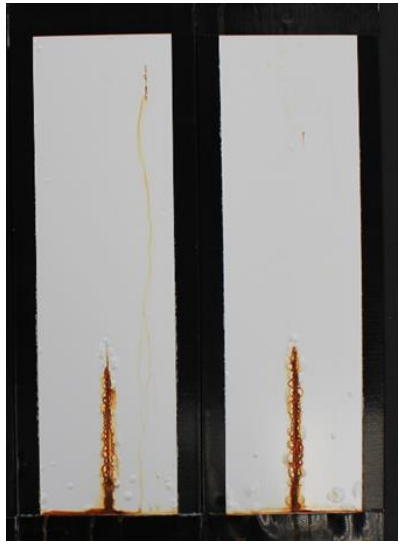
Semi-gloss DTM Enamels

Double Coats

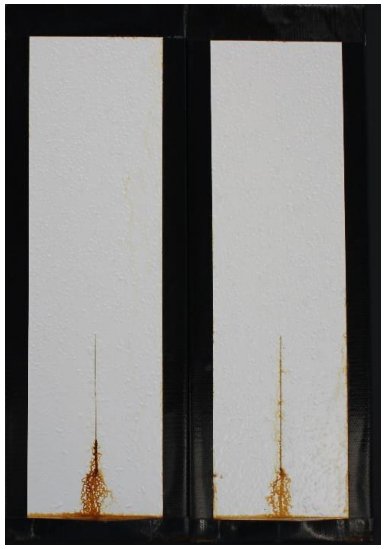
ASTM B117 Salt Spray
500 Hrs

CB1

CB2



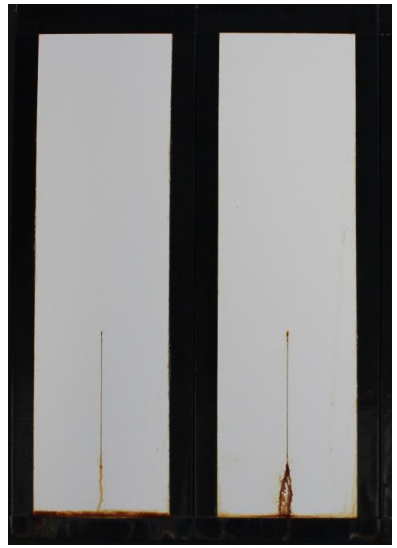
AD1



AD2

AD3

AD4



Semi-gloss DTM Enamels

Soy-based vs. Commercial Paints

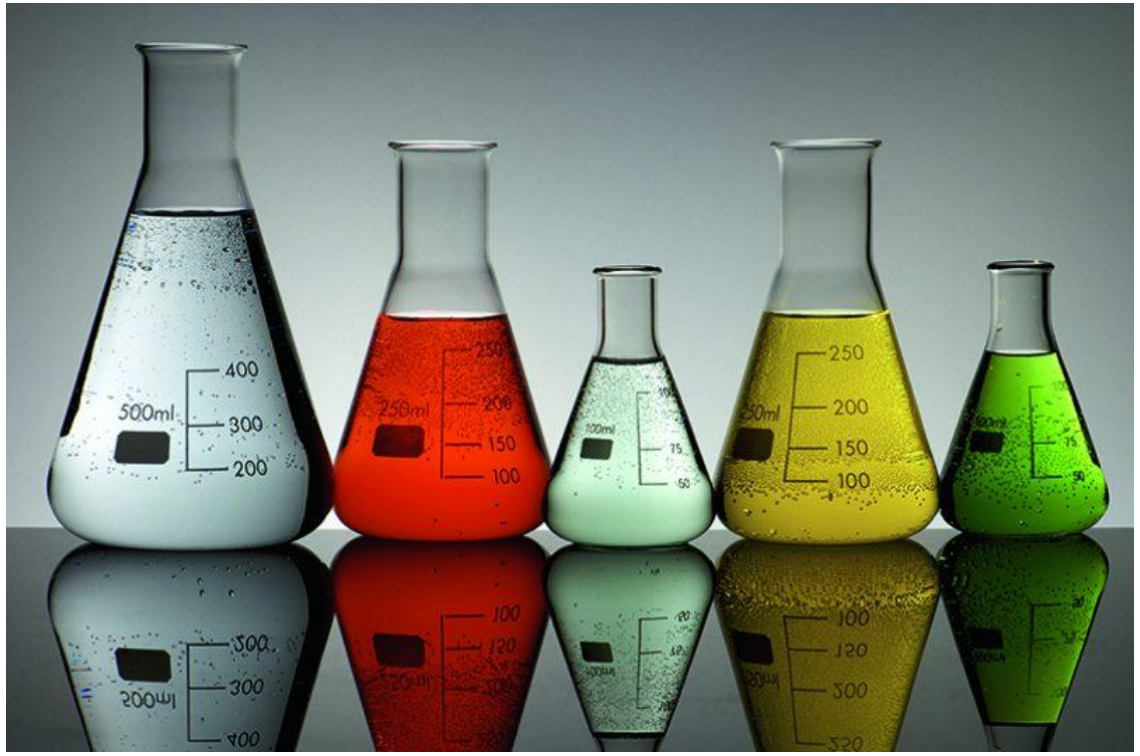
- ✓ + Adhesion
- ✓ Appearance
- ✓ + Hardness
- ✓ - Flexibility & Impact Resistance
- ✓ + Corrosion Resistance +
- ✓ - UV Resistance
- ✓ + % Biobased Content

Potential for interior applications over rigid metals or industrial primers.

Waterbased Soy-Alkyd Dispersions

Architectural Semi-Gloss Trim Enamels

- Soy-based Long Oil Alkyds (55-70% Soy Oil)
- Soy-based Medium Oil Alkyds (40-55% Soy Oil)
- Soy-based Short Oil Alkyds (<40% Soy Oil)
- Acrylic-modified Alkyds
- Resins 50-60% NV in Water
- Semi-gloss Paints ~35-40% Resin



Waterbased Soy-Alkyd Dispersions

Semi-Gloss Trim Enamels

Petroleum-Based Commercial Latex Resins	Bio-renewable WB Soy Alkyd Dispersions
Latex 1 – 100% Acrylic 50% NVW, MFFT 17°C	SA-1 – Medium oil alkyd emulsion 55% NVW
Latex 2 – Acrylic Copolymer 50% NVW, MFFT 14°C	SA-2 – Acrylic alkyd emulsion 60% NVW
	SA-3 – Short oil alkyd emulsion 50% NVW
	SA-4 – Long oil alkyd emulsion 55% NVW

Latex 1 & 2 same as coalescent study with P1 coalescing solvent

Waterbased Soy-Alkyd Dispersions

Semi-Gloss Trim Enamels

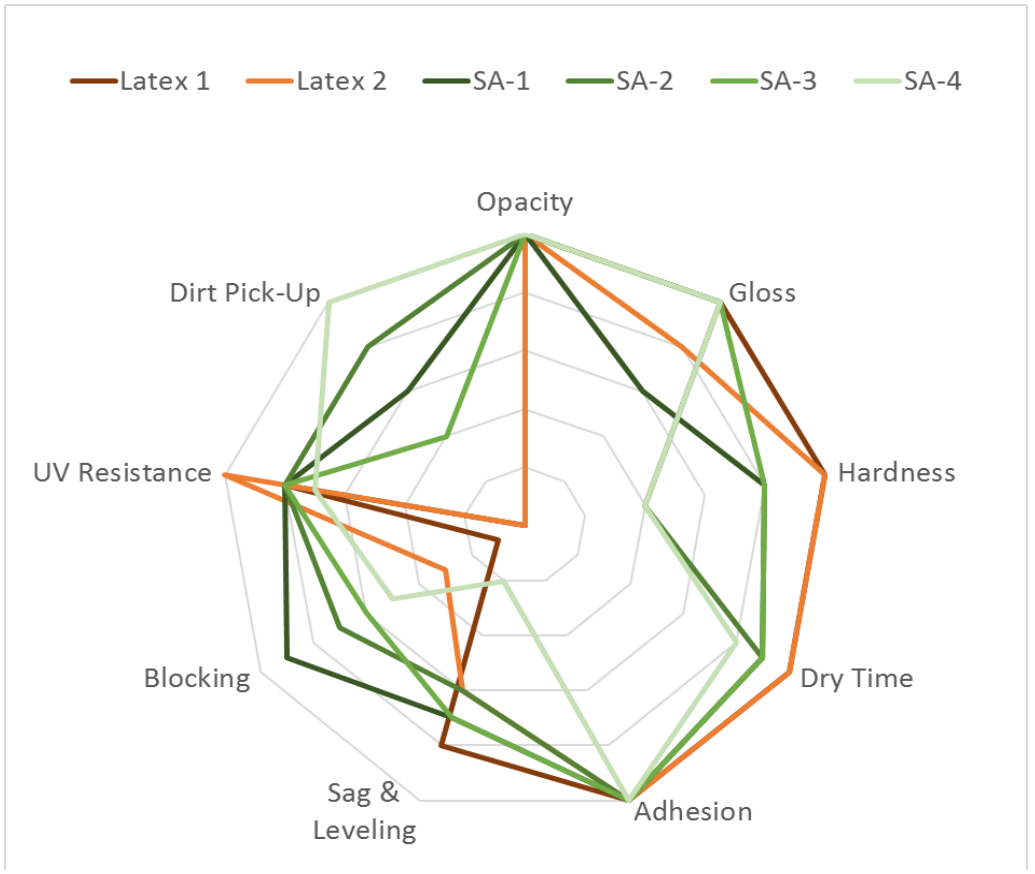
- 4 WB soy-alkyd dispersions
- 2 Petroleum-based latex emulsions

% PVC	23
% Weight Solids	45
% Volume Solids	33
Density	10.1
VOC (lb/gal)	0
VOC (g/L)	0

Description	Weight (Lbs)	Volume (Gals)
DI Water	232.39	27.83
Thicknener	5.79	0.87
Dispersant	10.24	1.16
Surfactant	2.04	0.23
Defoamer	2.74	0.33
Flow Control	4.59	0.53
Titanium Dioxide	179.14	5.36
Kaolin Clay	12.56	0.57
Calcium Carbonate	25.12	1.11
DI Water	48.27	2.82
Buffer	0.16	0.02
WB Soy-Alkyd Dispersion	387.68	44.13
DI Water	85.61	10.25
Drier Complex	4.24	0.49
Defoamer	1.87	0.22
Freeze-Thaw Stabilizer	7	1
Defoamer	2.82	0.32
Totals	1012	97

Waterbased Soy-Alkyd Dispersions

Semi-Gloss Trim Enamels



Note: Formulations not optimized.

WB Soy Alkyd Semi-Gloss Trim Enamels – Bio vs Petro

- ✓ Adhesion
- ✓ Application
- ✓ Appearance
- ✓ Hardness
- ✓ Block Resistance
- ✓ Dirt Pick-Up
- ✓ Weather Resistance
- ✓ Package Stability

Summary

- Improved block and dirt pick up resistance
- Formula optimizations
- Blend with latex

Architectural & Industrial Paints – Bio vs Petro

- ✓ Application
- ✓ Appearance
- ✓ Hardness
- ✓ Block Resistance
- ✓ Dirt Pick-Up
- ✓ Weather Resistance
- ✓ Package Stability
- ✓ % Biobased Content

Paints	Minimum Biobased Content (%)
Industrial Latex DTM	~ 5-6%
Architectural Latex Flats	~ 2-3%
Architectural Latex Semi-Gloss	~ 2-3%
Architectural WB Soy-Alkyd Semi-Gloss	38%

Waterbased Soy-Alkyd Dispersions

NEXT STEPS

Wood deck sealers & stains

Interior trim sealers & stains

Stay tuned…

Part 3: Soy Dispersants For Solvent-based Industrial Coatings

- **4 soy vs. 2 petroleum dispersants**
- **Coating formulations**
  - Soy-alkyd semi-gloss enamel
  - Bis Phenol A epoxy primer
- **Tests**
  - Fineness of dispersion
  - Gloss
  - Opacity
  - Color acceptance
  - Package stability

Soy Dispersants for Solvent-based
Industrial Coatings

Property	Test Method	Alkyd Paints	2K Epoxy Primers
Fineness of Dispersion	ASTM D1210	+	+
Gloss	ASTM D523	+	+
Opacity/Contrast Ratio	ASTM D2805	+	+
Color Acceptance	ASTM D5326	++	n/a
Package Stability	ASTM D1849	+	++

Soy alkyd – equivalent w/ improved color acceptance

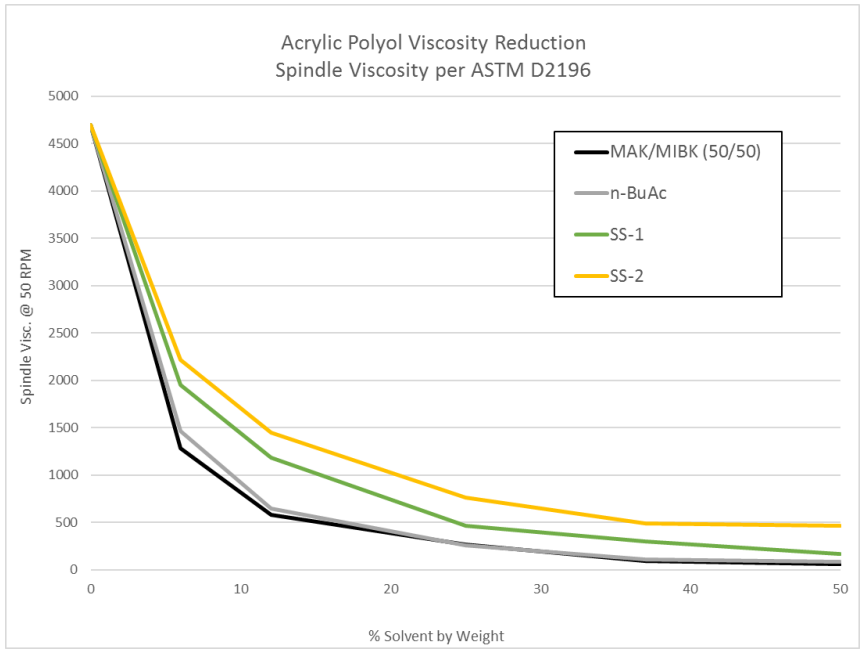
BPA epoxy – equivalent w/ improved package stability

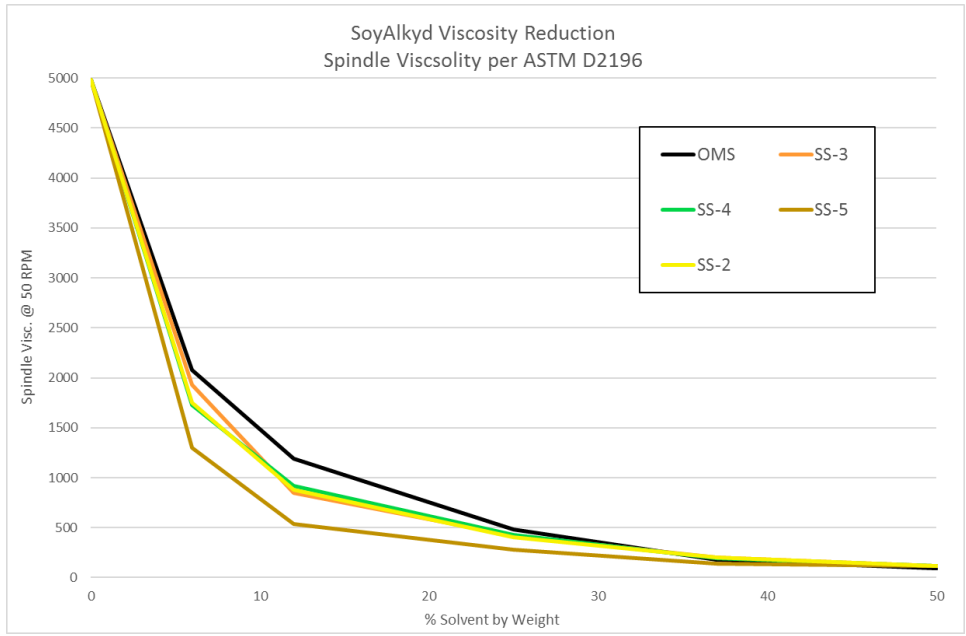
Part 4: Soy Solvents for Industrial Coatings

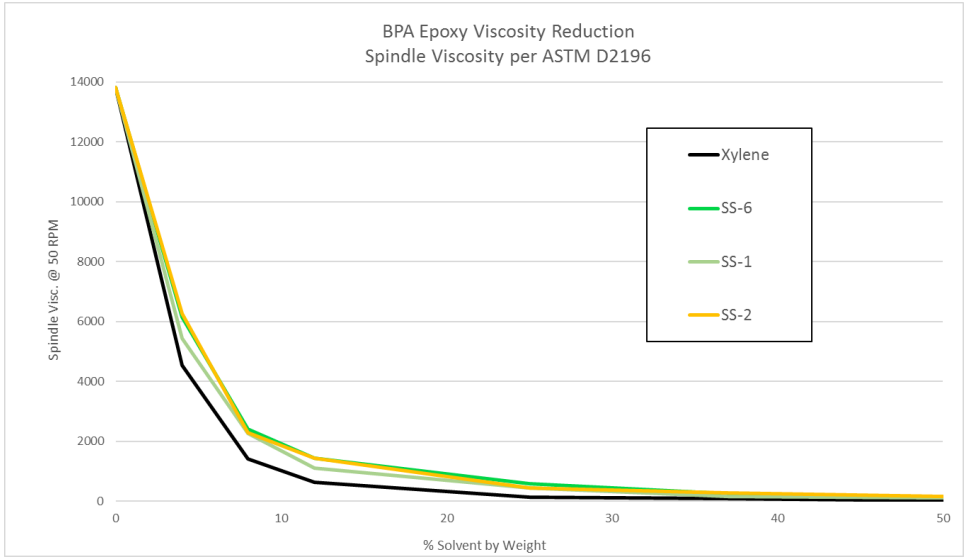
Resin Type	Petroleum Solvents	Soy Solvents	Levels of Incorporation (% Additional Solvent by Resin As-Supplied Weight)							
			0	4.17	6.25	8.33	12.5	25	37.5	50
Acrylic Polyol	n-BuAc MAK/MIBK (50/50)	SS-1 SS-2	x	-	x	-	x	x	x	x
Soy Alkyd	OMS	SS-2 SS-3 SS-4 SS-5	x	-	x	-	x	x	x	x
BPA Epoxy	Xylene	SS-1 SS-2 SS-6	x	x	-	x	x	x	x	x

- Key benefit – VOC reduction
- 6 soy vs 5 petroleum solvents
- 3 Resin systems
  - ✓Acrylic polyol
  - ✓Soy-alkyd
  - ✓BPA epoxy
- Viscosity reduction vs. % concentration

Soy Solvents – Concentration vs. Viscosity







Expected Use Level ~40%

Soy Solvents for Industrial Coatings

- **Summary with resin & solvent blends**
  - Acrylic polyol – not equivalent at 20%
  - Soya alkyd – equivalent at 30-35%
  - BPA epoxy – equivalent at 40%

- **Next steps**
  - Formulate into coatings
  - Possible replacement for PCBTF

SUMMARY:

Reduce Your Carbon Footprint with U.S. Soy

- Renewable, biobased carbons
- Low carbon footprint
- Diversity of applications
  - Enables chemistries for high performance applications
  - Low EH&S impact
- Economical
- Abundant supply


UNITED SOYBEAN BOARD™
US SOY
Kris Weigal
Omni Tech International
Table Top #25
708-625-7071
kweigal@omnitechintl.com
Read Our Article: Development of More-Sustainable Water-Based DTM Coatings, Part II
Featured in the September, 2024 issue of PCI Magazine
OMNI TECH
STRATEGIC SUSTAINABLE SOLUTIONS