SOYNEWUSES.ORG

Advancing Sustainable Coatings with U.S. Soybean Oil

Renewable Solutions for Coating Manufacturers

Kris Weigal

USE SOY FOR THAT

Coatings Trends & Technologies SUMMIT

September 2025

AGENDA

- UNITED SOYBEAN BOARD INTRODUCTION
- SOY: GLOBAL AND US SUPPLY
- SOY BUILDING BLOCKS
- SOY COATING MATERIALS
- PERFORMANCE TESTING OF COMMERICALLY AVAILABLE SOY COATING MATERIALS

The United Soybean Board

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

- Represents over 515,000 U.S. soybean producers in 31 states
- There are 77 farmer directors
- Promotes sustainability of U.S. Soy farming
  The budget supports research, promotion and education investment portfolios selected through USB's Portfolio Development Process
- Checkoff contributions of 0.5 % of the net market price per bushel sold
- The USB approved a program budget of $173.8 M for FY25

UNITED SOYBEAN BOARD™

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

FOOD + FUEL AND CHEMICALS

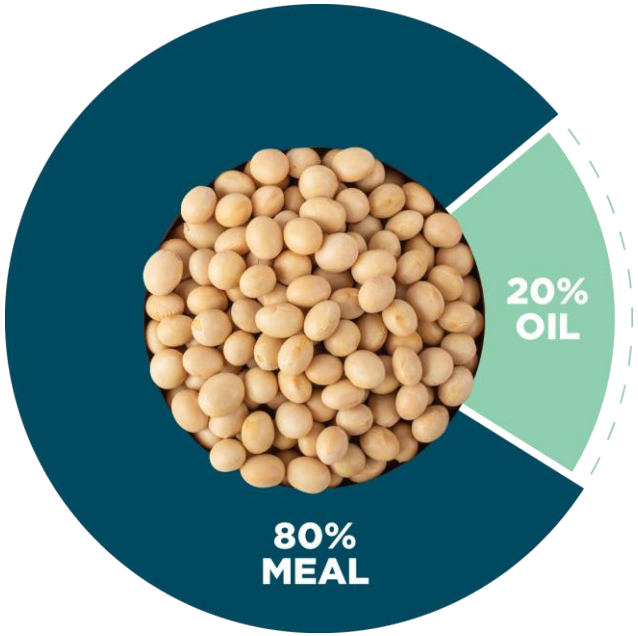
MEAL

95.34% Animal feed

3.72% Human consumption

0.50% Aquaculture

0.43% Industrial



OIL

42.7% Human consumption

47.9% Fuel

9.5% Industrial

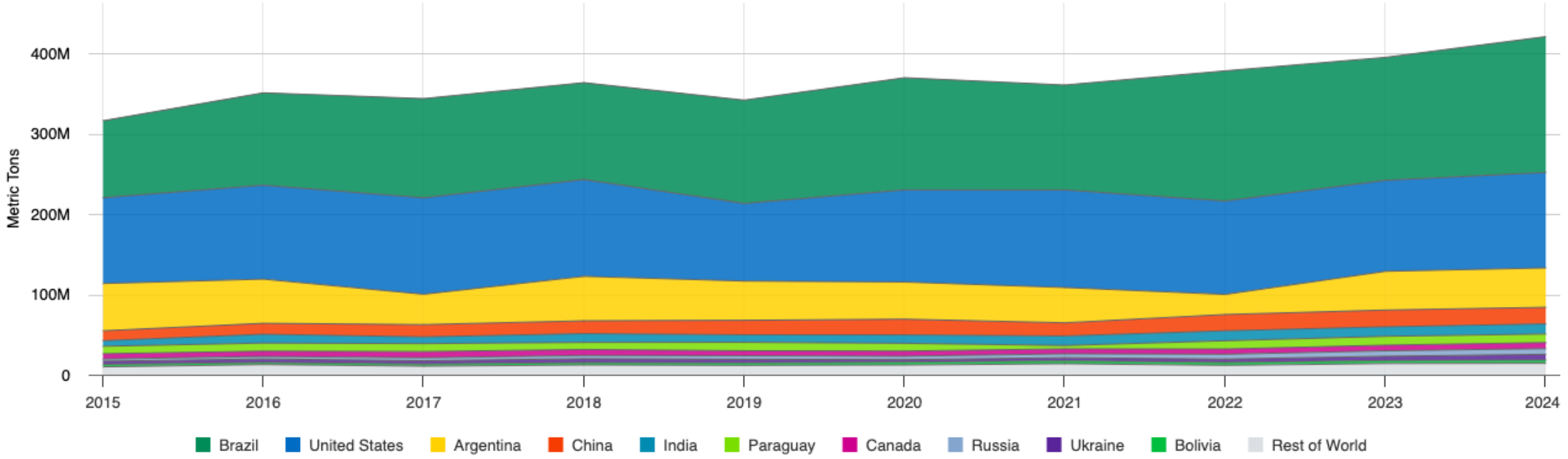
Source: Market View Database MY23/24 - 2025

"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

SOY IS A GLOBAL PRODUCT

10 Year Average MY 2015-2024	10-Year Compound Average Growth	2023/2024 Production	2024/2025 Production	Year over Year % Change
363.97 Million *Metric Tons*	**3%** *MY 2015-2024*	**394.97 Million** *Metric Tons*	**420.76 Million** *Metric Tons*	**7%**



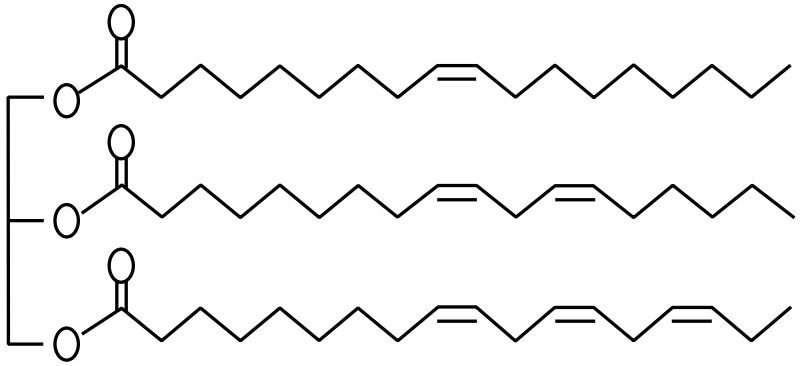
ABUNDANT SUPPLY OF U.S. SOY: 2024-25

267.6 B
Pounds of
Soybeans

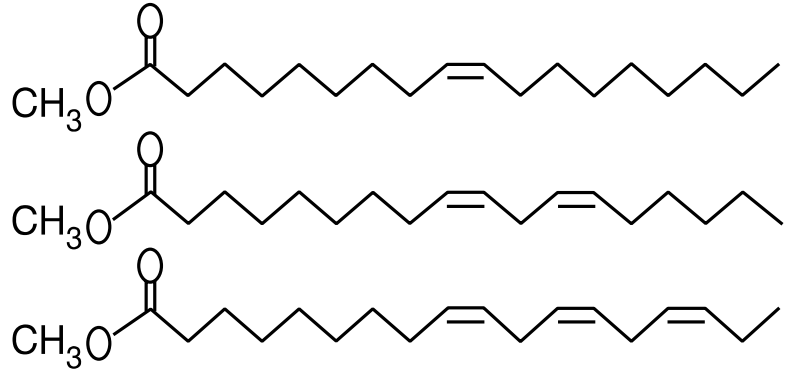
28.6 B
Pounds of
Soybean Oil

113.9 B
Pounds of
Soybean Meal

BASIC SOY OIL BUILDING BLOCKS

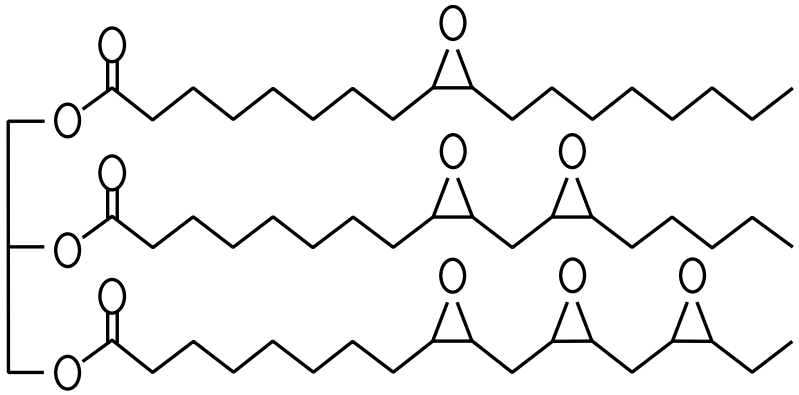


Soybean Oil

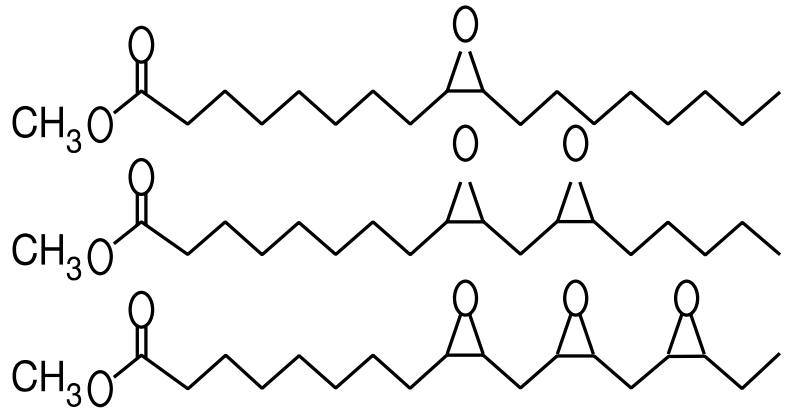


Methyl Soyate

Commercially Available



Epoxidized Soybean Oil



Epoxidized Methyl Soyate

Coatings

Soy Materials in Coatings

Soy Fatty Acid

- oleon — a natural chemistry
- CREMER
- Emery Oleochemicals
- Twin Rivers Technologies

Solvent borne

- covestro
- ARKEMA
- Polynt

Resin Emulsions

- ARKEMA
- covestro
- Polynt
- allnex — The Coating Resins Company

Soy Polyols

- Cargill
- A-LINE CORP
- panolam SURFACE SYSTEMS

Hydrocarbon Resins

- NEVILLE

Acrylic Dispersions

- Lubrizol

Powder Coating Resins

- BATTELLE

UV Cure Oligomers

- covestro
- allnex — The Coating Resins Company

Coatings

Soy Materials in Coatings

Solvents

VERTEC BIOSOLVENTS

SOYSOLV® BIOSOLVENTS

Stepan

Eco Safety Products

Wetting-Dispersing Aids

ETHOX

Lubrizol

EVONIK Leading Beyond Chemistry

Plasticizers

VALTRIS SPECIALTY CHEMICALS

Cargill®

Wax Emulsions

eurica GROUP

Coalescents

Cargill®

ACS TECHNICAL PRODUCTS

Pigment Dispersions

PAN® TECHNOLOGY ISO 9001:2015 CERTIFIED

USB Funded Project

(2321-106-0101, 2421-106-0101, 25-106-D-A-1-A)

- 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 (PCI April & Sept 2024)
  - ✓Alkyd emulsions for water-based architectural paints and wood stains
  - ✓Solvents for alkyd, epoxy & urethane industrial paints and wood coatings
  - ✓Wax emulsions for outdoor wood stains
  - ✓*Pigment dispersants for solvent-based industrial paints*
  - ✓*Soy Polyols for 2K polyurethane and melamine coatings*

STONEBRIDGE
COATINGS LABORATORY, INC.

Part 2. Waterbased Soy-Alkyd Emulsions

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 Emulsions

Semi-Gloss Trim Enamels

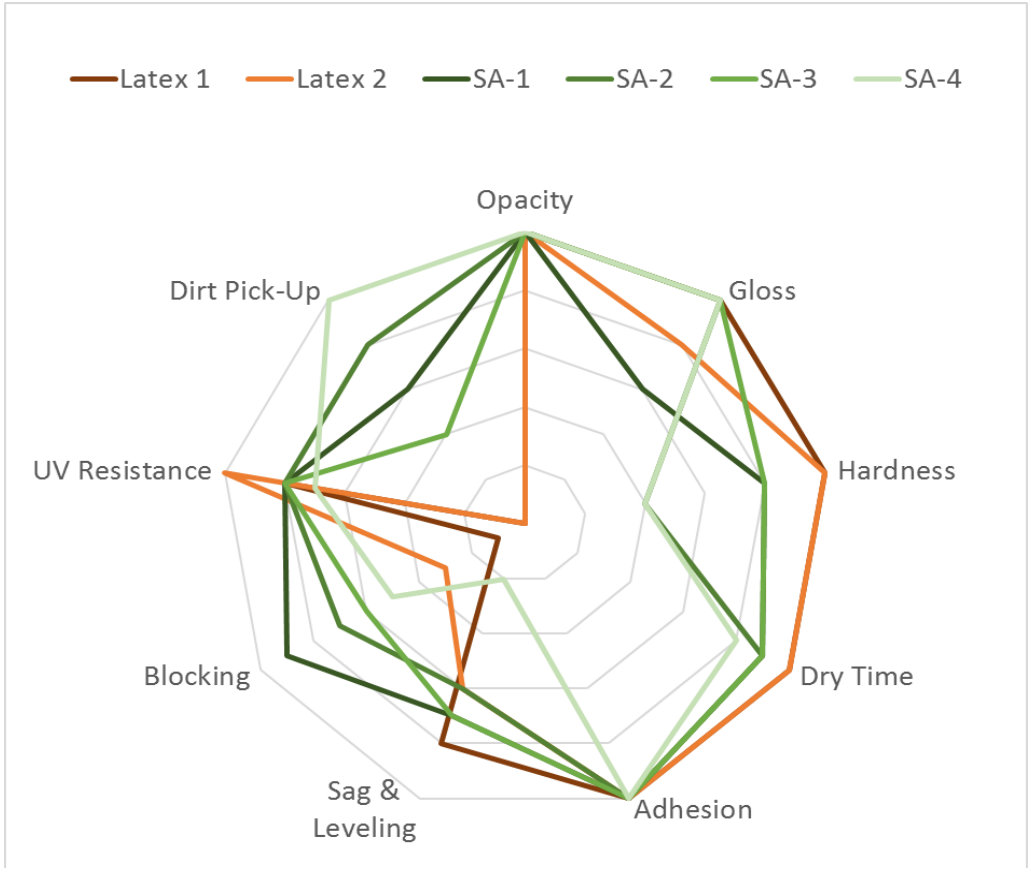
Petroleum-Based Commercial Latex Resins	Bio-renewable WB Soy Alkyd Dispersions
Latex 1 – 100% Acrylic 50% NVW, MFFT 17°C	SA-1 – Medium oil alkyd emulsion 55% NVW
Latex 2 – Acrylic Copolymer 50% NVW, MFFT 14°C	SA-2 – Acrylic alkyd emulsion 60% NVW
	SA-3 – Short oil alkyd emulsion 50% NVW
	SA-4 – Long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

% PVC	23
% Weight Solids	45
VOC (g/L)	0

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

Waterbased Soy-Alkyd Emulsions

Semi-Gloss Trim Enamels



SA-1 – Medium oil alkyd
SA-2 – Alkyd acrylic
SA-3 – Short oil alkyd
SA-4 – Long oil alkyd

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

Part 3. Waterbased Soy Resin Emulsions

Exterior Wood Deck Stains & Sealers

- 3 Commercial benchmark products
- 6 Soy stain & sealer formulations
- Over treated pine & cedar deck boards
- Properties
  - Appearance
  - Adhesion
  - Early water resistance
  - Scuff resistance
  - Thermal cycle resistance
  - UV resistance

Waterbased Soy Resin Emulsions

Exterior Wood Deck Stains & Sealers

Commercial Benchmarks (CS – Clear Sealer, S – Stain)	Bio-renewable WB Soy Alkyd Emulsions
CS1 & S1 – WB clear and semi-transparent stain (Acrylic)	Soy1 – Long oil alkyd emulsion 55% NVW
CS2 & S2 – WB clear (Acrylic) and semi-transparent stain (Alkyd)	Soy2 – Oil modified urethane emulsion 45% NVW
CS3 & S3 – WB clear (Alkyd) and semi-transparent stain (Acrylic)	Soy3 – Acrylic alkyd emulsion 45% NVW
	Soy4 – Hydrocarbon resin emulsion 67% NVW

Waterbased Soy Resin Emulsions

Exterior Wood Deck Stains & Sealers

- 4 WB soy clear sealer & stain formulations
- 3 Commercial benchmarks
- Over treated pine & cedar

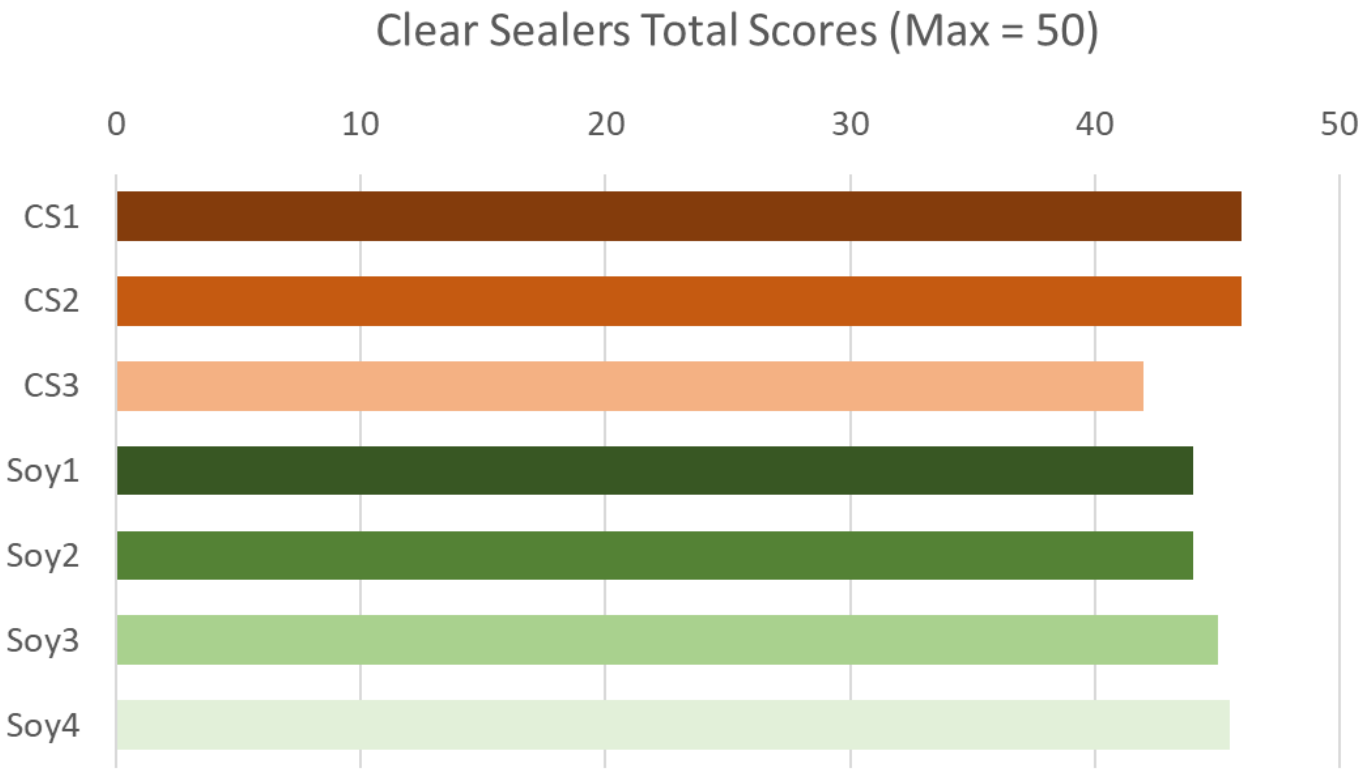
% Weight Solids	26.3
% Volume Solids	24
Density	8.54
VOC (lb/gal)	0
VOC (g/L)	0.09

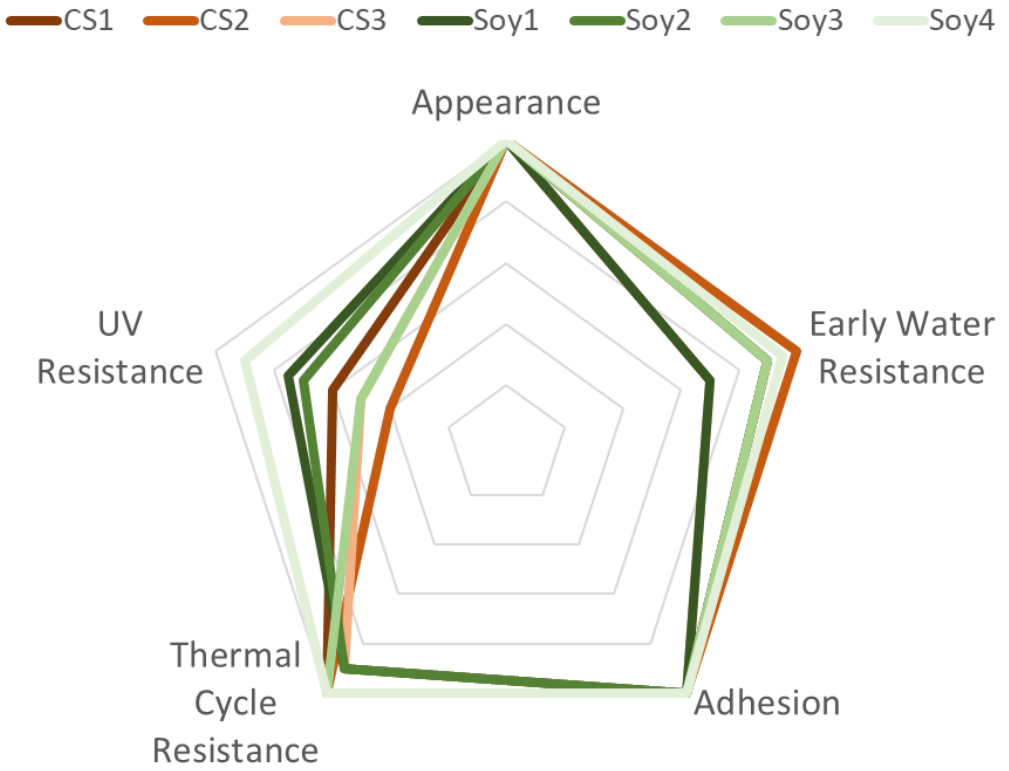
Description	Weight (Lbs)	Volume (Gals)
Deionized Water	295.56	35.43
Rheology Modifier	4.32	0.65
Defoamer	3.01	0.35
Buffer	0.86	0.11
Surfactant	1.31	0.17
Deionized Water	120.63	14.46
Soy Alkyd Emulsion	276.49	31.43
Freeze-Thaw Stabilizer	4.43	0.51
Cobalt-Free Drier	2.95	0.34
Soy Wax Emulsion	113.89	14.07
Transparent Yellow Oxide	16.63	1.39
Transparent Red Oxide	2.39	0.19
Transparent Burnt Umber	7.82	0.59
Transparent Raw Umber	3.71	0.30
Totals	854	100

Waterbased Soy Resin Emulsions

Exterior Wood Deck Stains & Sealers

Clear Sealers



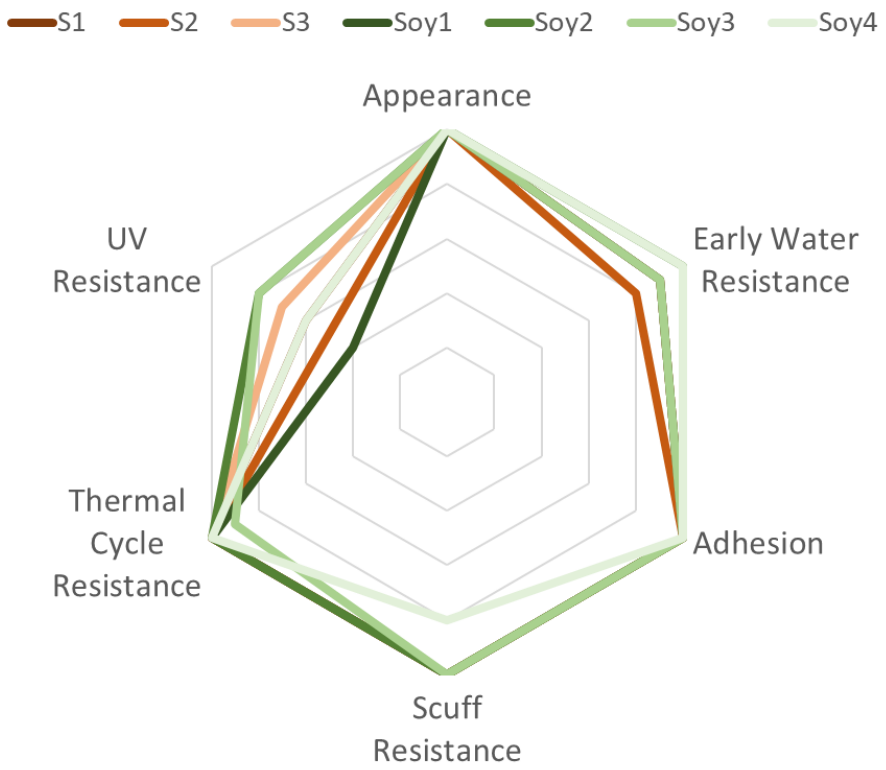


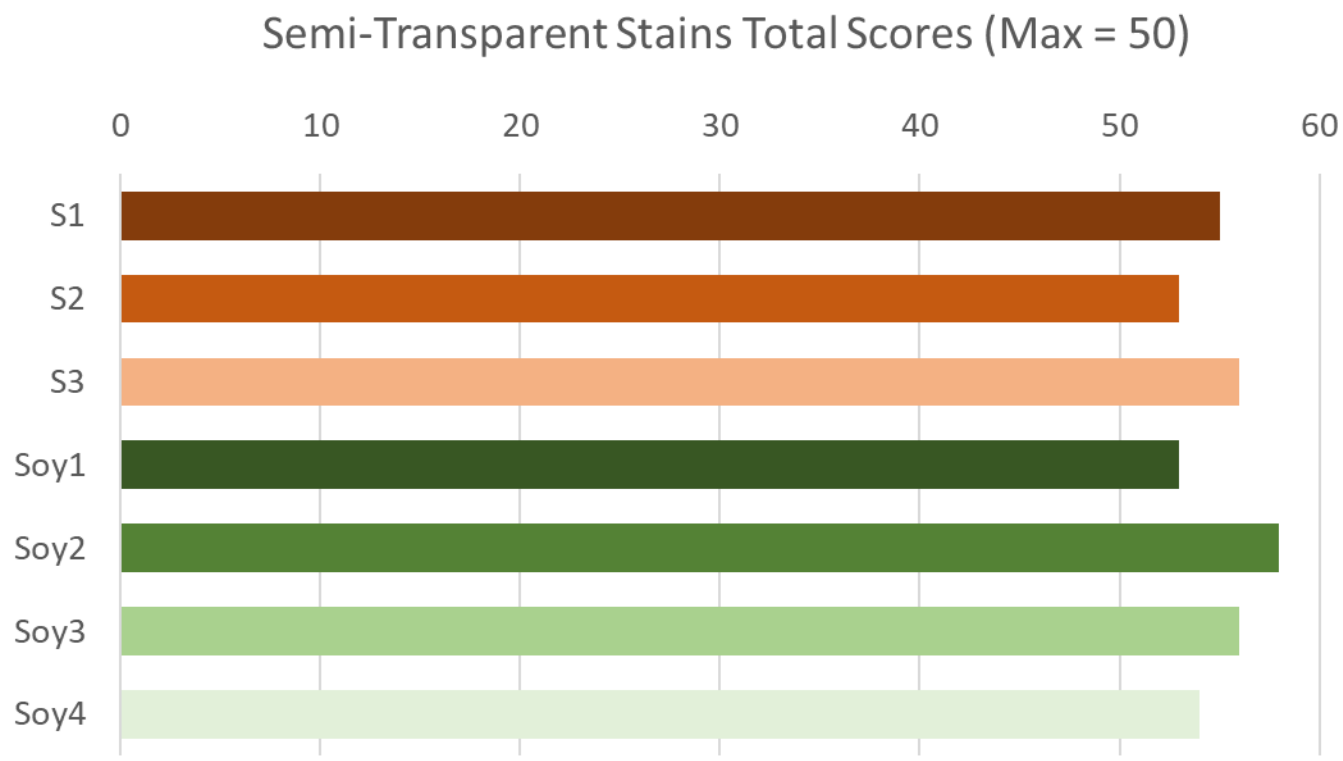
Soy1 – Long Oil alkyd
Soy2 – High solids, anionic stabilized, soybean oil modified urethane polymer
Soy3 – Acrylic modified alkyd resin emulsion
Soy4 – Low molecular weight C9 hydrocarbon resin modified with soy

Waterbased Soy Resin Emulsions

Exterior Wood Deck Stains & Sealers

Semi-Transparent Stains





Soy1 – Long Oil alkyd
Soy2 – High solids, anionic stabilized, soybean oil modified urethane polymer
Soy3 – Acrylic modified alkyd resin emulsion
Soy4 – Low molecular weight C9 hydrocarbon resin modified with soy

WB Soy Exterior Wood Deck Stains & Sealers

= Appearance

= Adhesion

+ Early Water Resistance

= Thermal Shock Resistance

+ UV Resistance

Summary

45% by volume soy-based raw materials comparable to petroleum-based commercial benchmarks

Part 4. Waterbased Soy Resin Emulsions

Interior Wood Stains & Clears

- 4 Commercial benchmark products
- 4 Soy semi-gloss clear & stain formulations
- Over red oak trim boards
- Properties
  - Appearance
  - Adhesion
  - Wear resistance
  - Chemical & stain resistance
  - Water resistance

Waterbased Soy Resin Emulsions

Interior Wood Stains & Clears

Commercial Benchmarks	Bio-renewable WB Soy Alkyd Emulsions
CB1 – WB Combination stain & satin clear in one product (Acrylic)	Soy1 – Long oil alkyd emulsion 55% NVW
CB2 – WB Stain with semi-gloss clear topcoat (Acrylic)	Soy2 – Oil modified urethane emulsion 45% NVW
CB3 – WB Stain with semi-gloss clear topcoat (Acrylic)	Soy3 – Acrylic alkyd emulsion 45% NVW
CB4 – SB Stain with semi-gloss clear topcoat (Alkyd stain, Acrylic topcoat)	Soy4 – Hydrocarbon resin emulsion 67% NVW

Waterbased Soy Resin Emulsions

Interior Wood Stains & Clears

- 4 WB soy semi-gloss clear & stain formulations
- 4 Commercial benchmarks
- Stain + clear over red oak, 7 days min dry

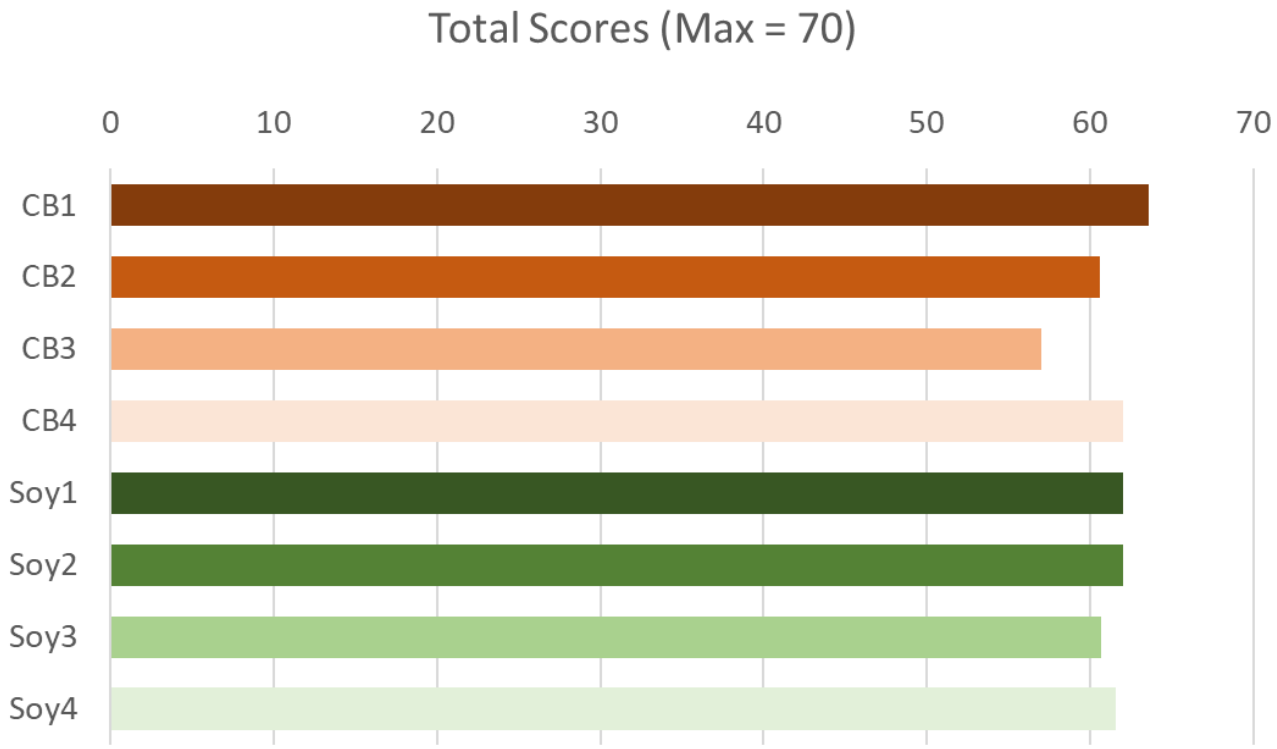
% Weight Solids	25
% Volume Solids	24
Density	8.45
VOC (lb/gal)	0
VOC (g/L)	0.09

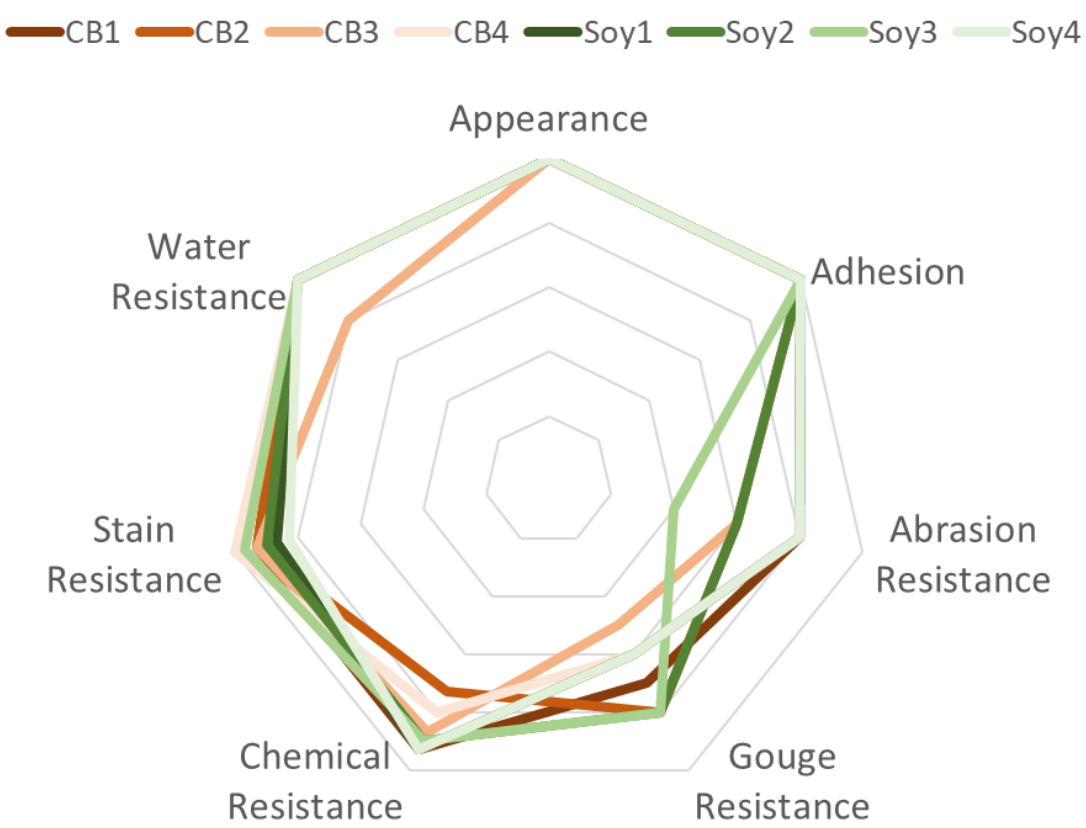
Raw Material	Weight (Lbs)	Volume (Gals)
Deionized Water	303.29	36.30
Rheology Modifier	4.44	0.66
Defoamer	3.09	0.36
Buffer	0.88	0.11
Surfactant	1.34	0.17
Deionized Water	123.79	14.83
Soy Alkyd Emulsion	283.73	32.23
Freeze-Thaw Stabilizer	4.55	0.53
Cobalt-Free Drier	3.03	0.35
Soy Wax Emulsion	116.87	14.40
Totals	845	100

Stains made with a blend of transparent iron oxides & umbers (2.3% PVC)

Waterbased Soy Resin Emulsions

Interior Wood Stains & Clears





Soy1 – Long Oil alkyd
Soy2 – High solids, anionic stabilized, soybean oil modified urethane polymer
Soy3 – Acrylic modified alkyd resin emulsion
Soy4 – Low molecular weight C9 hydrocarbon resin modified with soy

WB Soy Interior Stains & Clears – Bio vs Petro

= Appearance

= Adhesion

= Abrasion & Gouge Resistance

= Chemical & Stain Resistance

= Water Resistance

Summary

46% by volume soy-based raw materials comparable to petroleum-based commercial benchmarks

Part 5. VOC Reduction with Soy Solvents

Interior Solvent-based Semi-Gloss Wood Floor Coatings

3 VOC Limits Nationwide

- 450g/L Federal EPA
- 350g/L OTC Phase I
- 275g/L CARB & OTC Phase II

PCBTF solvent used to reduce VOC – problems:

- Toxic, carcinogen (CA Prop 65)
- Banned in Europe and some US states (Toxic Air Contaminant lists)
- CA to phase out PCBTF in auto-refinish by 2030
- Not domestically sourced

VOC Reduction with Soy Solvents

Interior Solvent-based Semi-Gloss Wood Floor Coatings

Can soy solvents be used to replace PCBTF?

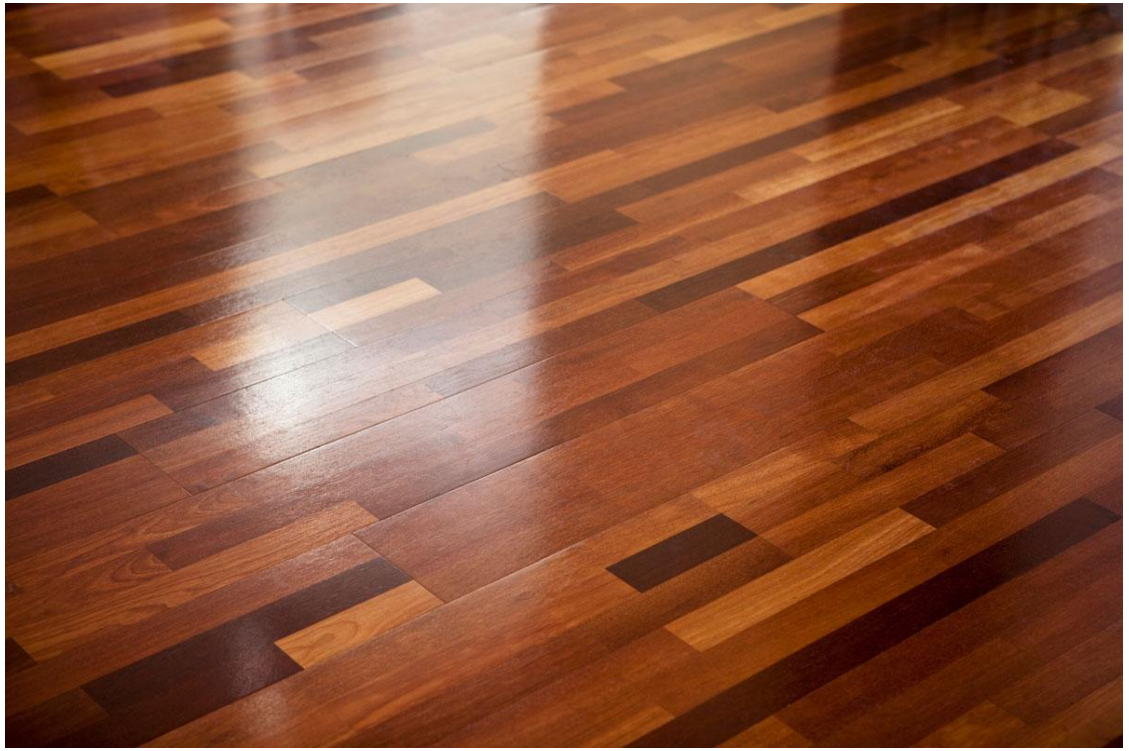
6 Commercial benchmark wood floor topcoats
(Multiple VOCs)

<u>10 Semi-gloss clearcoat formulations</u>

- 2 Soy oil modified polyurethane resins (OMUs)
- Odorless mineral spirits (OMS) > VOC limit
- 4 partial OMS replacements to reduce VOCs to compliance
  - PCBTF
  - 3 different soy solvents

VOC Reduction with Soy Solvents

Interior Solvent-based Semi-Gloss Wood Floor Coatings



	Label VOC (g/L)
Commercial Benchmark 1	< 350
Commercial Benchmark 2	< 450
Commercial Benchmark 3	< 450
Commercial Benchmark 4	< 550
Commercial Benchmark 5	< 450
Commercial Benchmark 6	< 275

VOC Reduction with Soy Solvents

Interior Solvent-based Semi-Gloss Wood Floor Coatings

Raw Material	OMU1 Weight (Lbs)	OMU1 Volume (Gals)	OMU2 Weight (Lbs)	OMU2 Volume (Gals)
Soy Oil Modified Urethane	609.02	79.09	598.80	74.48
OMS	108.58	17.12	109.38	17.25
Cobalt-Free Drier	7.41	1.01	8.36	1.14
MEKO-Free Anti-skinning Agent	5.48	0.69	6.21	0.78
Soy Solvent	16.46	2.08	50.20	6.35
Totals	747	100	773	100
% NVW	58.8		63.9	
% NVV	52.3		57.8	
Density	7.47		7.73	
VOC (lb/gal)	2.91		2.29	
VOC (g/L)	349		275	

10 Clearcoats Total

Solvent	OMU1 Series VOC (g/L)	OMU2 Series VOC (g/L)
100% OMS	367	330
w/ PCBTF	350	275
w/ Soy Solvent 1	350	275
w/ Soy Solvent 2	350	275
w/ Soy Solvent 3	350	275

Red oak & maple boards
220 grit sanding
3 coats with overnight dry in between coats

VOC Reduction with Soy Solvents

Interior Solvent-based Semi-Gloss Wood Floor Coatings

(16 Topcoats Tested)

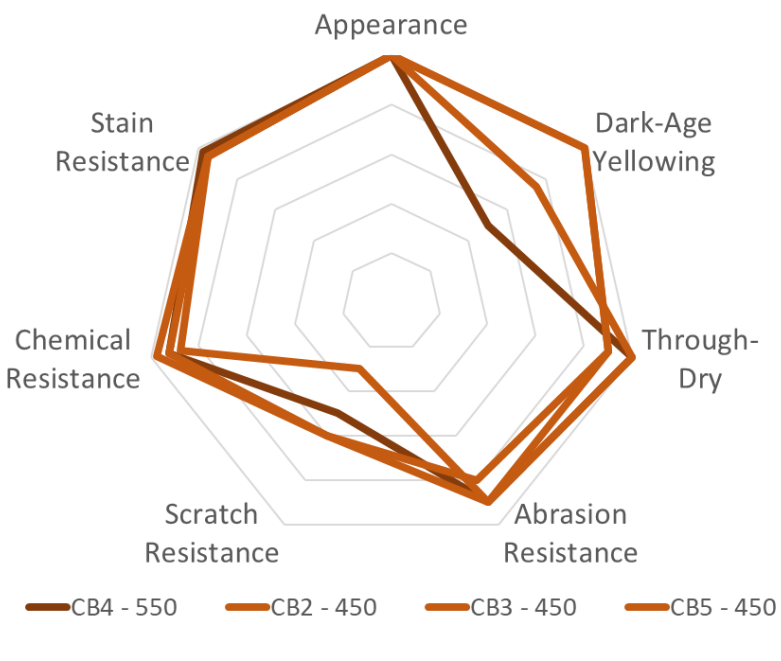
- Dry Times
- Appearance
- Yellowing Upon Exposure to Darkness
- Abrasion Resistance
- Scratch Resistance

- Chemical Resistance
  - Boiling water
  - Ethyl acetate
  - Vinegar
  - Windex (ammonia)
- Stain Resistance
  - Coffee
  - Mustard
  - Olive oil
  - Red wine

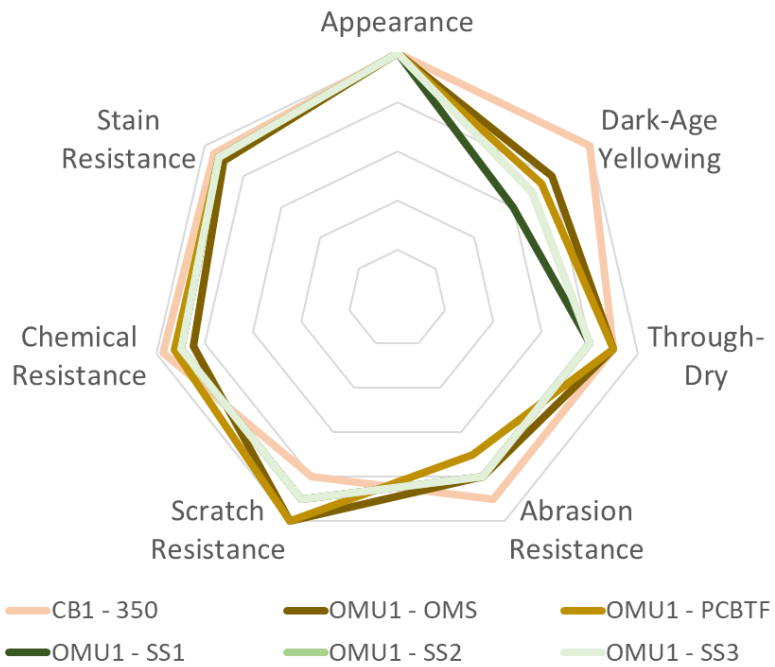
VOC Reduction with Soy Solvents

Interior Solvent-based Semi-Gloss Wood Floor Coatings

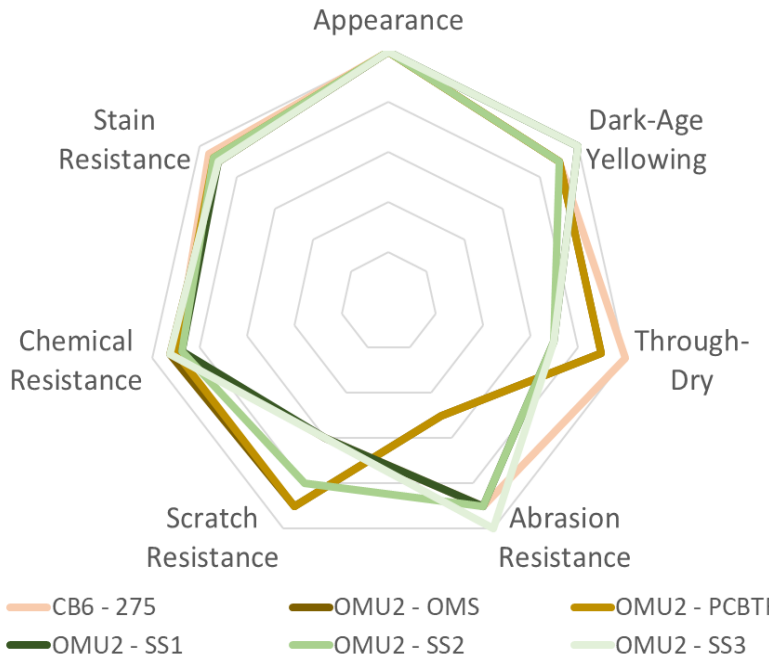
Higher VOC Benchmarks



350g/L VOC Series

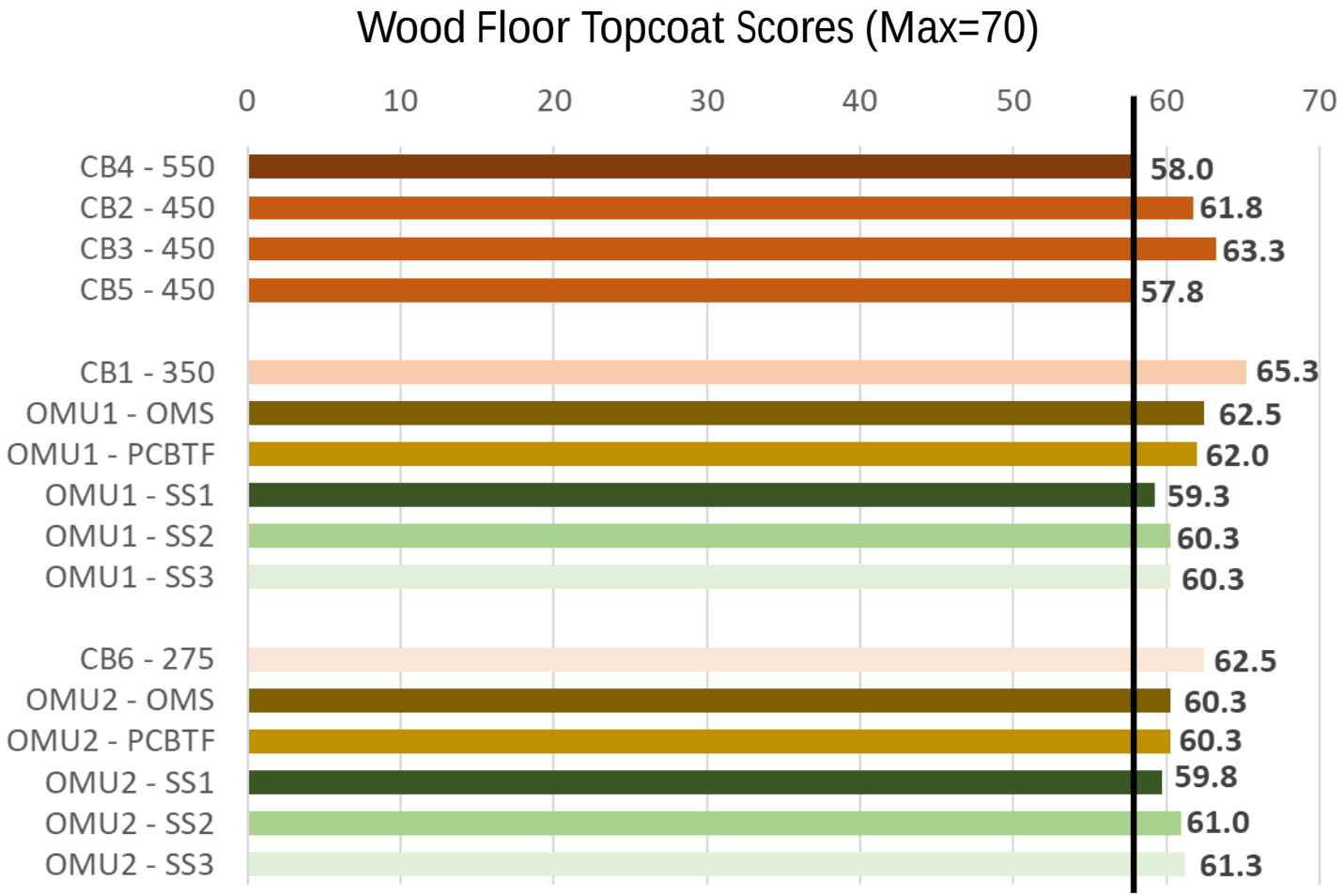


275g/L VOC Series



VOC Reduction with Soy Solvents

Interior Solvent-based Semi-Gloss Wood Floor Coatings



Higher VOC Benchmarks (>450g/L)

350g/L VOC Series

275g/L VOC Series

VOC Reduction with Soy Solvents

Interior Solvent-based Semi-Gloss Wood Floor Coatings

Higher VOC Benchmarks

- Poor scratch resistance
- Some dark yellowing

350g/L VOC Series

- Soy OMU--Better scratch resistance
- CB1 best overall
- Soy solvents vs PCBTF
  - Slight improvement in abrasion resistance
  - Slight loss in dry time and dark yellowing

275g/L VOC Series

- Soy OMU--Better scratch resistance
- CB6 best overall
- Soy solvents vs PCBTF
  - Significant improvement in abrasion resistance
  - Loss in dry time and slightly less scratch resistant

VOC Reduction with Soy Solvents

Interior Solvent-based Semi-Gloss Wood Floor Coatings

- ✓ VOC Reduction
- ✓ Non-carcinogenic
- ✓ HAPs-free
- ✓ Approach Comparable Performance
- ✓ Deficiencies may be improved through formula optimization

Next Steps

Duplicate assessment with satin finish wood floor topcoats & expand to Industrial Maintenance Coatings

SUMMARY:

Reduce Your Carbon Footprint with U.S. Soy

- Renewable, biobased carbons
- Abundantly available - U.S.
- Diversity of applications
  - Enables chemistries for high performance applications
  - Low EH&S impact and VOCs
- Economical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