Coatings Trends & Technologies SUMMIT

Meeting Sustainability Standards with Bio-based Additives

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Contents

- Sustainability
  - Many Guidelines
  - Many Standards
    - *Coatings-specific sustainability standards*
    - *USDA BioPreferred Program*
- Bio-based Materials: Terminology & Methods
- Approaches to Increasing Additive Bio-based Content:
  - Rheology Modifiers
  - Wetting Agents
  - Dispersants
  - Waxes
  - Defoamers

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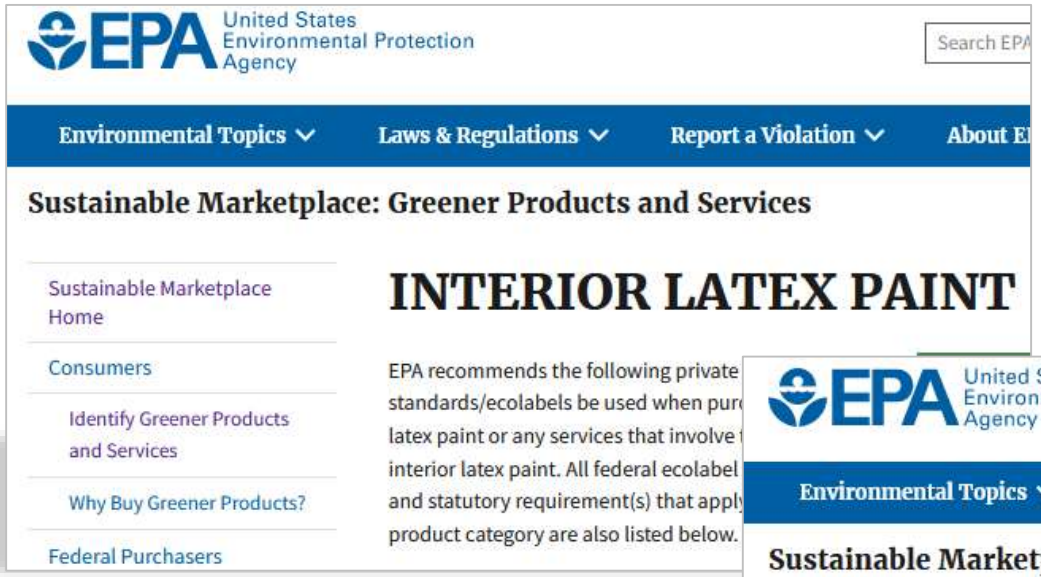
A Panoply of Sustainability Principles

- Minimal negative effects to health and living organisms
  - Non toxic
  - Biocide-free
  - Low SVOCs
- Minimal contribution to the production of greenhouse gases
  - Low to no VOCs
- Avoidance of non-biodegradable organic materials that persist in the environment
- Selection of materials preferentially made from renewable, bio-based carbon sources over fossil-derived sources

Additional Key Points for Sustainable Additive Development

- Label-free and broad compliance with regulations and inventories
- Sustainable & certified raw materials/recycled raw materials
- Shortest possible supply chains/sustainable sourcing
- Energy-efficient production
- Improving the properties of final coating formulations => extend the lifespan
- Readily biodegradable, not classified as microplastic
- PTFE-free/PTFE alternatives
- Non-food competing feedstocks

A Panoply of Standards and Ecolabels



https://www.epa.gov/greenerproducts

The USDA BioPreferred® Program Specifies Minimum Bio-based Content Levels

- USDA BioPreferred® Program (139+ Federal Purchasing categories, including ***Intermediates – Chemicals*** *(min. 22%)* category)

https://www.biopreferred.gov/BioPreferred/

USDA BioPreferred® Minimum Bio-Based Content

Adhesives: 24%

Concrete Repair Materials – Leveling: 23%, Patching: 69%

2K Epoxy Systems: 23%

Exterior Paints & Coatings: 83%

Inks: 32 to 67% depending on type

Interior Paints & Coatings: 20-67% depending on type

Mulch and Compost Materials: 95%

Powder Coatings: 34%

Traffic and Zone Marking Paints: 30%

Wastewater Systems Coatings: 47%

Water Tank Coatings: 59%

Wood and Concrete Stains: 39%

Benefits of Bio-based Products

In addition to strengthening the economy and supporting rural America, biobased products have many benefits, including:

- Help address climate change by offering renewable alternatives to petroleum-based products
- Sequester carbon dioxide, lowering the concentration of greenhouse gasses in the atmosphere that contribute to climate change
- Are generally safer for people and the environment than their petroleum-based counterparts
- Perform as well as or better than many non-biobased alternatives

BioPreferred Program Fact Sheet [PDF]. USDA BioPreferred Website https://www.biopreferred.gov/BioPreferred/faces/pages/AboutBioPreferred.xhtml#, PDF download.

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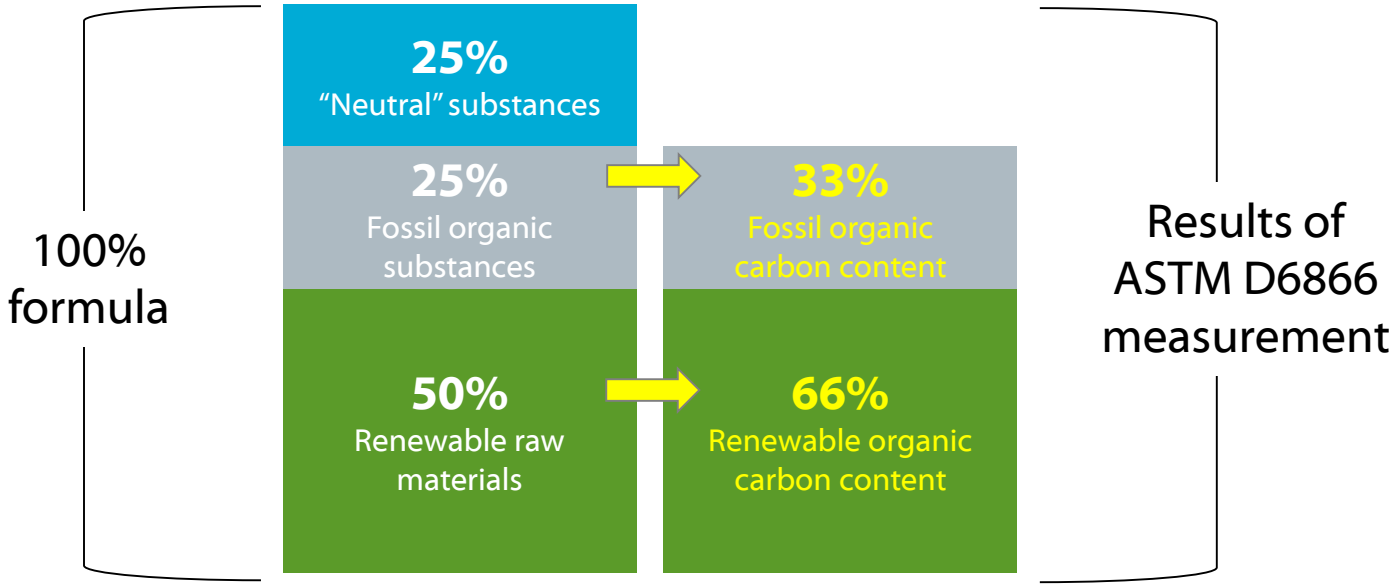
  - Defoamers

Bio-based Definition and Test Methods

Bio-Based Carbon Content

- **Bio-based products are derived from biomass rather than fossil/petroleum sources.**
- Bio-based carbon content is calculated with respect to the active organic substance.
- Biomass contains some Carbon-14 isotope, aka ^{14}C. Fossil-derived materials no longer contain ^{14}C and only contain regular ^{12}C.
- Test method ASTM D6866 quantifies the ratio of ^{14}C to ^{12}C in the test material and compares it to the ratio in a 100% bio-based reference material.
- Other methods include ISO 16620-2 and CSN EN 16640.

Bio-based Content is Calculated on the Organic Carbon Content



Neutral All non-organic carbon compounds such as water, minerals (SiO_2, TiO_2, Al_2O_3, etc.), ammonia, ammonium salts, alkali hydroxides, and also inorganic carbon ($CaCO_3$, etc.)

Fossil All organic carbon-containing compounds from petrochemical feedstock

Renewable All organic carbon-containing compounds from biomass feedstock (^{14}C detectable)

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Examples of Additive Components with Inherent Bio-based Content

- Some additives, and components used to make additives, are already inherently bio-based. These include materials such as:
  - Natural waxes
  - Fatty acids
  - Biopolymers
  - Vegetable oils

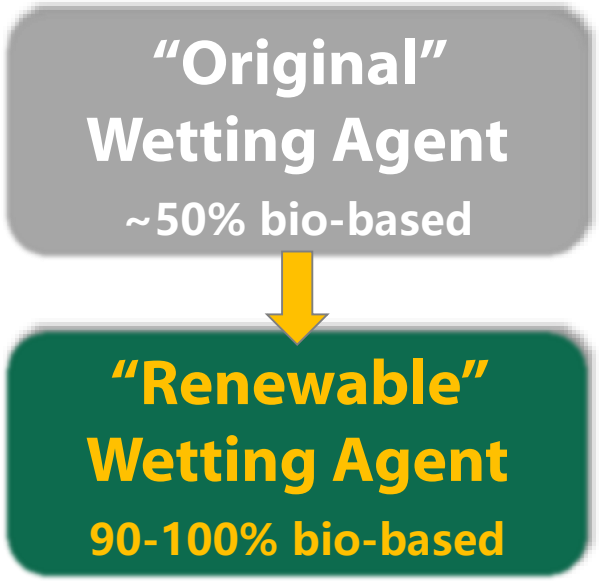
Additives with Enhanced Bio-based Content and Identical Composition and Performance

Some components of additives that are not inherently bio-based can be alternatively synthesized from a biomass feedstock rather than a petrochemical feedstock.

The bio-based content of many additives can in this way be increased, sometimes dramatically so.

Additives with Enhanced Bio-based Content and Identical Composition and Performance

Example 1:

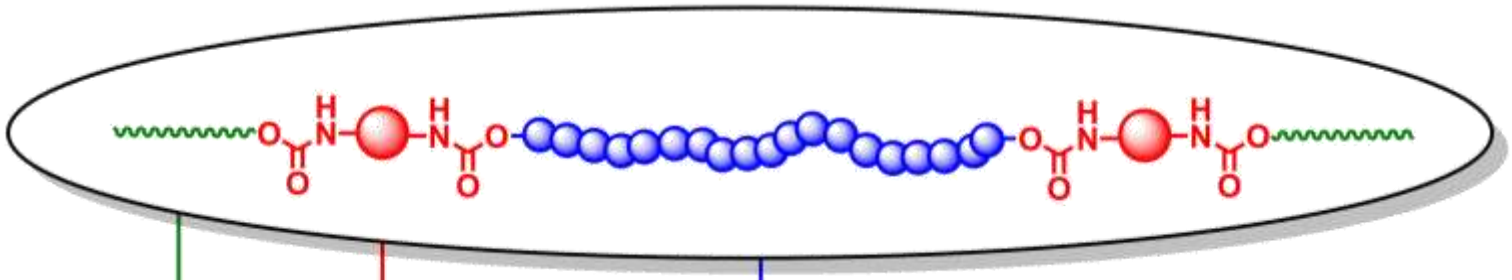


Example 2:

The resulting "Renewable" versions of the additives have the same composition and performance as the original additives, and also meet the same regulatory compliances as the originals.

This simplifies their introduction into existing formulations and is an easy way to enhance the bio-based content of the final product.

Example: HEUR-type Rheology Modifiers



≈5% ≈5% 90%

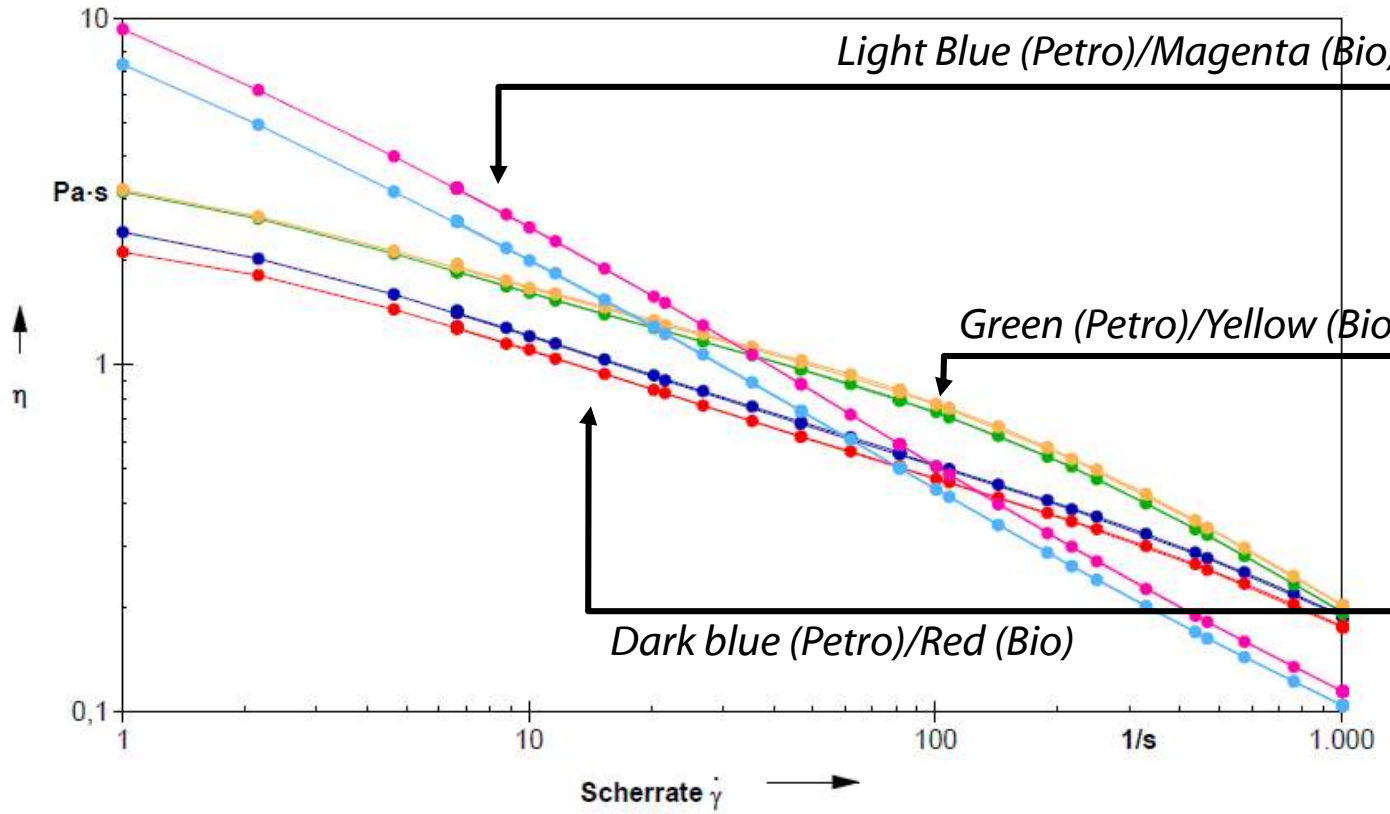
Today: 0% bio-based

- ✓ **Non food-competing feedstocks**
- ✓ **Certified & palm oil-free**

Aim: 100% bio-based

- **Hydrophobic end-capping:** Already partially bio-based
- **Bifunctional bridge:** Not bio-based (yet)
- **Water-soluble spacer:** **Key building block**

Rheology Modifiers with Enhanced Bio-based Content and Identical Performance to the Originals

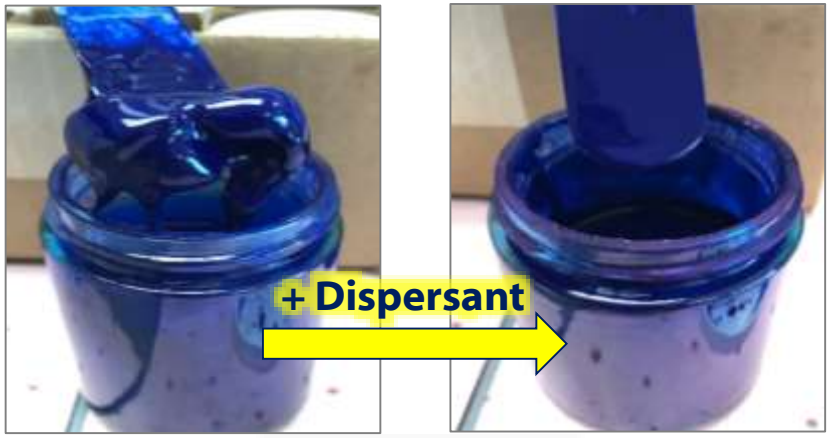


Strongly Pseudoplastic HEUR Rheology Modifier
50-60% Bio-based

Moderately Pseudoplastic HEUR Rheology Modifier
80-90% Bio-based

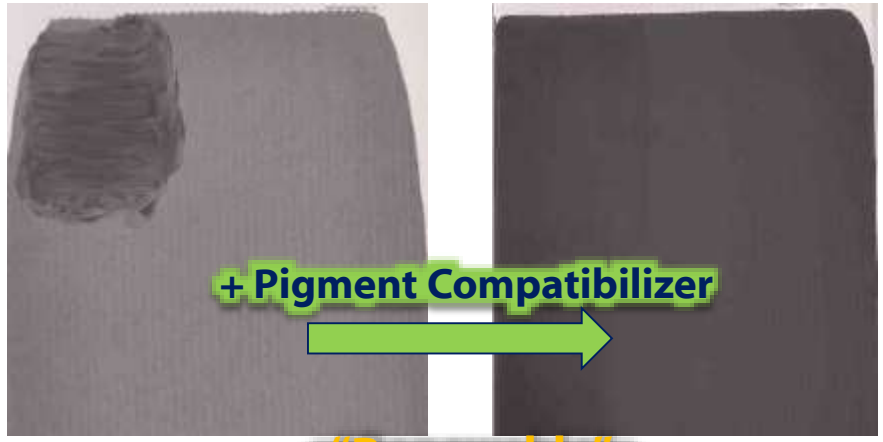
Newtonian HEUR Rheology Modifier
90-100% Bio-based

Bio-based Surfactants and Dispersant for a Wide Range of Applications



"Renewable" Dispersant
90-100% bio-based

"Renewable" Wetting Agent
90-100% bio-based



"Renewable" Compatibilizer
90-100% bio-based

Bio-based Surfactants and Dispersant for a Wide Range of Applications

Product	Chemistry	"Neutral" substances/ Fossil substances/ **Renewable substances, %**	**Renewable organic carbon content [ASTM D6866]**	Readily biodegradable? [OECD 301]
Dispersing Agent	Polyglycol ester	**0 / 0 / 100**	90-100%	Yes
Substrate Wetting Agent	Ester	**0 / 0 / 100**	90-100%	Yes
Pigment Wetting Agent/Compatibilizer	Nonionic compounds	**0 / 0 / 100**	90-100%	Yes

Bio-based vs. Biodegradable

Bio-Based Carbon Content

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Biodegradability

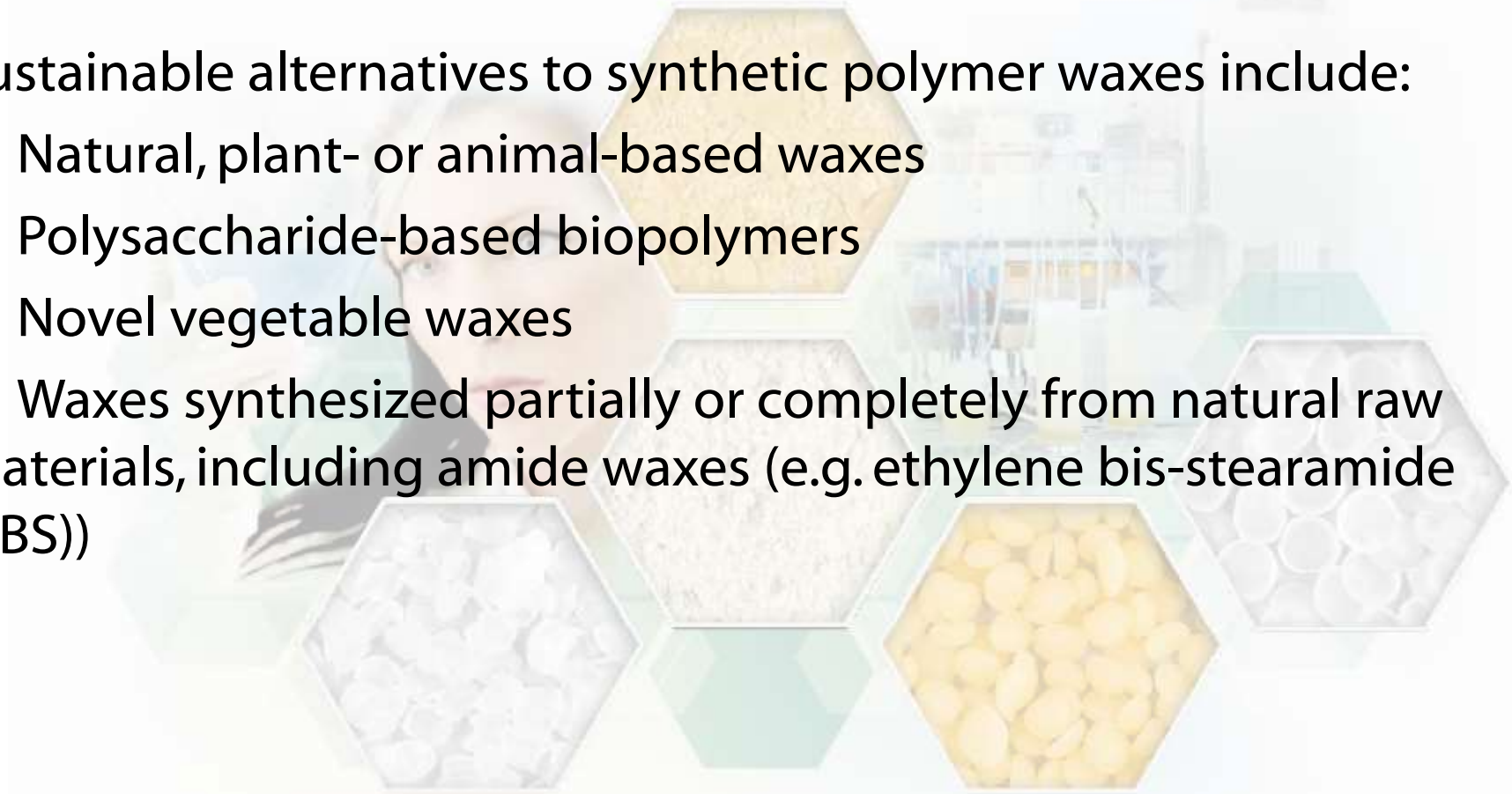
- **Biodegradability is the capacity for organic materials to decompose after interactions with biological elements.**
- Test methods OECD 301 A through F generally measure CO_2 release or oxygen consumption over time as the test material decomposes under controlled conditions.
- Other methods include *EN 13432 & EN 14995* (Biodegradability & compostability).

- Bio-based materials are not necessarily also biodegradable, and vice versa.

Waxes with Enhanced Bio-based Content

Sustainable alternatives to synthetic polymer waxes include:

- Natural, plant- or animal-based waxes
- Polysaccharide-based biopolymers
- Novel vegetable waxes
- Waxes synthesized partially or completely from natural raw materials, including amide waxes (e.g. ethylene bis-stearamide (EBS))

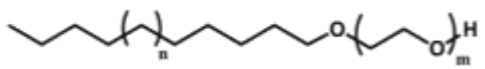


Bilger M, Leyh T, Schütz S. 07/08-2022. Wax Additives – True Multi-Talents. European Coatings Journal.

Multiple Defoamer Components Have Potential for Bio-based Substitution

Defoamer

Emulsifiers



e.g. polyglycol ethers and esters, sorbitanes, …

Natural Wax

Vegetable Oils

Rheology Additive(s)
Biocide(s)
Carrier Medium
(e.g. water, glycols, …)

Typically **0.01-0.3%** in end-formulation

Defoamer Composition

Carrier

Water, Polyether glycols, Oils, Polydimethylsiloxane (PDMS)

- Liquids that transport actives to the surface
- Spread on the surface
- Lowers the defoamer viscosity

Actives

3D Siloxane, PDMS, Organo-Modified Siloxane (OMS) Hydrophobic Silica, Wax, Oil

- Adsorb surfactant molecules
- Enter, spread, and bridge lamella

Emulsifiers

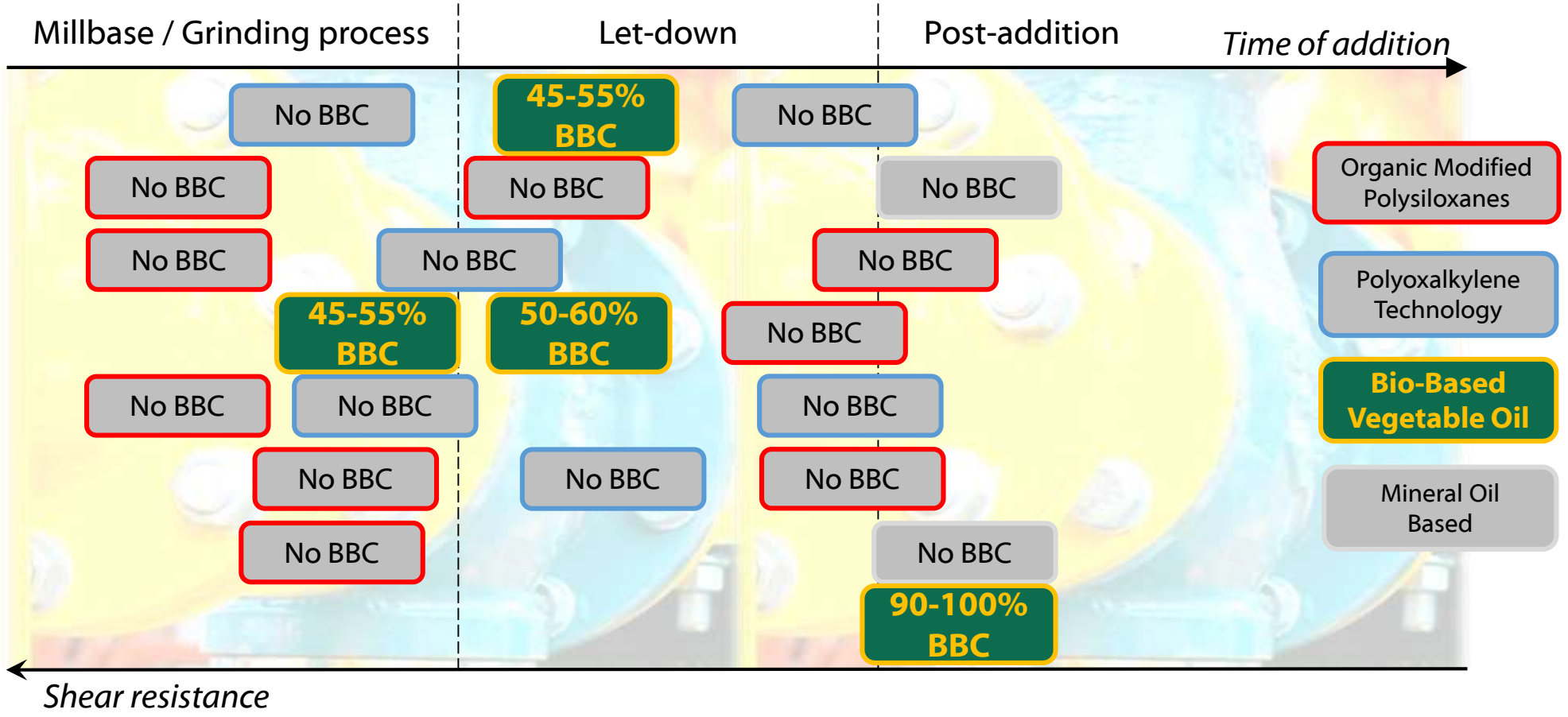
Non-ionic ethoxylate surfactants, OMS

- Adjust compatibility of defoamers in the system
- Control spreading of the defoamer at the surface

Some of the materials in each major defoamer component category have the potential to be substituted with a bio-sourced version.

Bio-based Defoamers for Every Stage of Addition

Defoamers recommended for Industrial and Wood Coatings



Bio-based Additives Have Potential for Top Performance

Top Five Recommended Defoamers for Architectural Coatings

Rank, % Bio-based content (BBC)	Type
1st-Recommended, No BBC	100% || poa
1st-Rec, 45-55% BBC	veg || poa
2nd-Rec, No BBC	m
2nd-Rec, 50-60% BBC	100% || veg || poa
2nd-Rec, 45-55% BBC	e (50%) || veg

poa = polyoxalkylene technology
e = emulsion
veg = vegetable oil
m = mineral oil

Interior Wall Paint Example:
45-55%Bio-based Defoamer with Excellent Persistence

Wall paint based on EVA + x% defoamer	AS in %	Dosage in %	IKA stirring test % foam	Stability/ compatibility after 24 h	Roller application on PVC chart	Leveling on glass, 150 µm wet film thickness		
						Total	CR	OP
Without defoamer	--	--	36.9	homogeneous	1	10	n	n
Competitor	53.5	0.56	14.7	homogeneous	2	10	n	n
Reference 1	29.0	1.00	6.9	homogeneous	4	5	s	n
Reference 2	50.0	0.60	3.2	homogeneous	4	8	f	f
45-55% BBC	**100.0**	**0.30**	**1.1**	**homogeneous**	**7**	**9**	**n**	**n**
		0.15	**3.3**	**homogeneous**	**5**	**10**	**n**	**n**

Defoamer
45-55% bio-based

- *Type:* Natural oil/POA
- Active content: **100%**
- Stability: pH 3-11

AS = Active substance, CR = Cratering, OP = Orange peel, n = none, f = few, s = some
Ranking from insufficient (1) to excellent (10)

Binder Synthesis Example: 50-60%Bio-based Defoamer with Good Persistence & Easy Incorporation Properties

Acrylic + 0.2% defoamer	Dissolver test, foam in %		Stability after 24 h	Leveling on glass, 100 µm wet film thickness					Roller application	
				Wet film			Dry film			
	Foam build up	Foam collapse		over all	CR	OP	over all	CR	Wet	Dry
Without defoamer	55	55	homogeneous	10	n	n	10	n	1	4
Competitor	25	10	few oil droplets on top	10	n	n	3	m	5	8
Reference 1	10	0 after 15 s	some streaks on top	9	f	n	5	f	8	10
Reference 2	25	20	foam on top	10	n	n	9	n	1	10
45-55% BBC	10	0 after 5 s	many streaks on top	5	s	n	1	m	9	10
50-60% BBC	0	0 after 5 s	homogeneous	9	n	n	9	n	9	10

Defoamer
~50-60% bio-based

- *Type:* Natural oil/POA
- Active content: **100%**
- Stability: pH 3-11

AS = Active substance, CR = Cratering, OP = Orange peel, n = none, f = few, s = some
Ranking from insufficient (1) to excellent (10)

Summary

Conclusions

Despite the number and degree of fragmentation of sustainability standards and strategies in the marketplace, improvements can be made through the inclusion of bio-based materials in coating formulations.

Existing rheology modifier, wetting agent, dispersant, wax, and defoamer additive technology can sometimes be substantially improved for bio-based content with no compromise in performance or composition and no labeling changes.

Any Questions?

Thank you

Vielen Dank

MÜNZING
CREATING ADDITIVE VALUE