HIGH PERFORMANCE, SUSTAINABLE WAX AND SILICONE EMUSLIONS FOR INDUSTRIAL COATINGS APPLICATIONS

COATINGS TRENDS & TECHNOLOGIES, SEPTEMBER 2023

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A CHT GROUP COMPANY

CHT

07.09.2023 Bruce Berglund, Construction & Assembly, Coatings

CONTENT

1) CHT
2) Sustainability
3) Bio-Based Materials
4) Bio-Based Waxes
5) Waxes to Additives - Emulsification
6) Bio-Sourced Wax Emulsion Barrier Coating Additives
7) Bio-Based Carbon Content
8) Low Cyclic Silicone Gum Emulsion
9) Conclusions

BRUCE BERGLUND

- Outdoors / Wilderness / Fishing
- Reading (Christian, Nature, Business, Health)
- Family – Andre and Mark, Brandy
- Hockey, Music (trumpet)
- Education (PhD, MBA) – Always Learning
- Minnesota Roots, Florida Home
- Focus on Health

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CONSERVATION AND SUSTAINABILITY IS NOT NEW

The conservation of waters, forests, soils, and wildlife are all involved with the conservation of the human spirit. The goal we all strive toward is happiness, contentment, the dignity of the individual, and the good life.

Without love of the land, conservation lacks meaning or purpose, for only in a deep and inherent feeling for the land can there be dedication in preserving it.

Ethical and moral questions and how we answer them may determine whether primal scenes will continue to be a source of joy and comfort to future generations. The decisions are ours and we have to search our minds and souls for the right answers... We must be eternally vigilant, embrace the broad concept of an environmental ethic to survive.

If we can change our priorities, achieve balance and understanding in our roles as human beings in a complex world, the coming era can well be that of a richer civilization, not its end. Sigurd Olson

OUR COMPANY IS A FOUNDATION

The non-profit Reinhold-Beitlich-Foundation promotes:

- Social commitment to young people
- Science and research in the field of chemistry
- Research on renewable raw materials
- Promotion of environmental and nature conservation

Vision

- CHT is the preferred partner and leading reference for sustainable chemical solutions in our markets, worldwide!

CHT TECHNICAL CORE COMPETENCIES

COMPETITIVE ADVANTAGE

CHEMISTRY	RAW MATERIALS	SYNTHESIS	PROCESSING	FUNCTIONS
Wax	▶ Polyolefins ▶ Polyester ▶ **Natural Waxes**	▶ Oxidation	▶ **Emulsifying** ▶ **Formulating** ▶ **Dispersing** ▶ **Mixing** ▶ **Milling**	▶ **Surface Modification** ▶ **Hydrophobicity** ▶ Defoaming ▶ Wetting / Dispersing ▶ **Rheology** ▶ **Film Formation**
Silicone	▶ **PDMS** ▶ Siloxane Oligomers ▶ Silanes	▶ Equilibration ▶ Hydrosilylation ▶ Polycondensation		
Polysaccharide	▶ **Guar** ▶ **Xanthan** ▶ **Tamarind**	▶ Alkoxylation		
Synthetic Polymers[1)]	▶ Acrylics ▶ Isocyantes ▶ Polyols	▶ Polymerisation		

1) Polyacrylates, polyurethanes, polyester

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SUSTAINABLE RAW MATERIALS

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BIO-BASED NON-FOSSIL MATERIALS

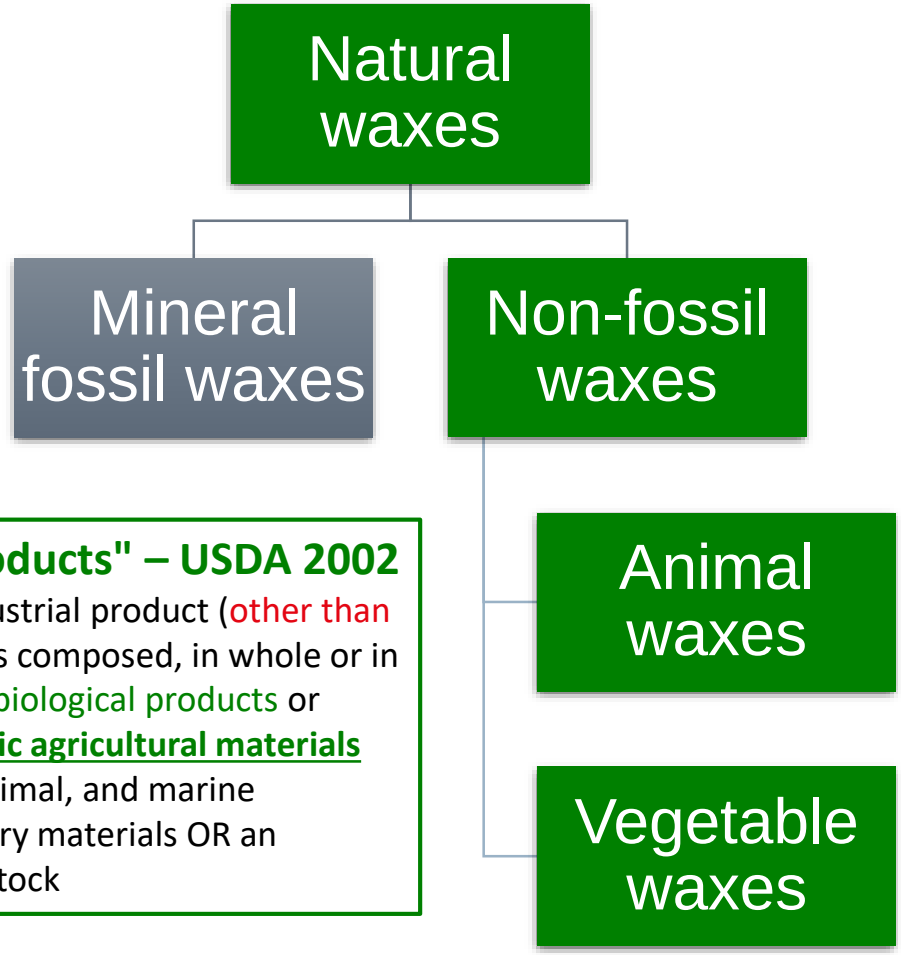
Animals

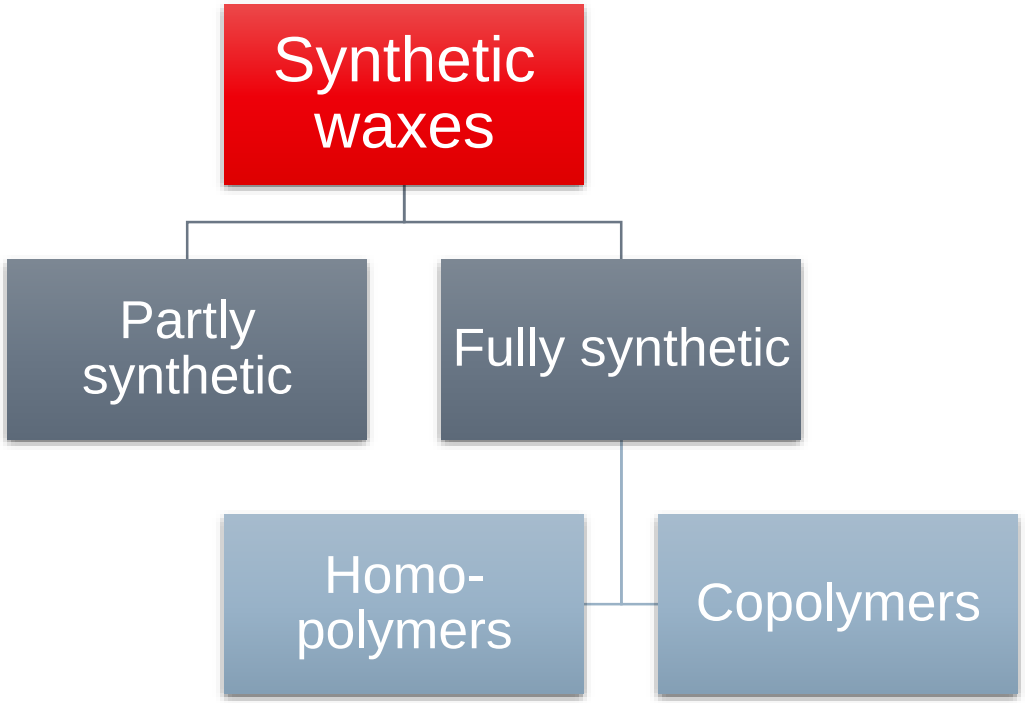
Casein (from milk)	Binders
Waxes	Additives

Plants

Cellulosic resins	Binders / Monomers / Rheology Modifiers
Gum Rosin	
Tall Oil Rosins	
Natural Rubber	
Alkyds	
PLA (Polylactic acid)	
Polyurethanes (diols)	
Polysaccharides (Guar, Xanthum, Tamarind)	
Soybean, Linseed, Castor, Corn Oils	Plasticizers, Drying oils
Alcohols (ethanol), Esters	Solvents
Waxes	Additives

WAXES - BIO-BASED





"Bio-based products" – USDA 2002

Commercial or industrial product (other than food or feed) that is composed, in whole or in significant part, of biological products or **renewable domestic agricultural materials** (including plant, animal, and marine materials) or forestry materials OR an intermediate feedstock

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BIO-BASED NON-FOSSIL WAXES

Animal Waxes

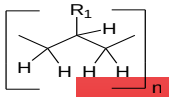
Bees wax – From the abdominal glands of the honeybee	Moderately hard, tacky
Shellac wax – From the female lac bug in India and Thailand	Hardness, Gloss, Glue
Lanolin wax – From sheep's wool	Hydrophobic, Moisturizing
Other waxes?	Hydrophobic?, Oleophobic?

BIO-BASED NON-FOSSIL WAXES

Vegetable Waxes

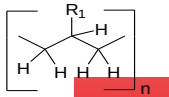
Carnauba (palm) wax – From the carnauba tree in Brazil	Slip, Gloss, Clarity
Rice bran wax – From rice oil	Gloss, Hydrophobic Emulsion stabilization, Rheology, Binding, Plasticizing
Candelilla wax – From small shrub in northern Mexico and SW US	Hardness, Gloss, Rheology
Laurel wax – From the fruit of the Myrica pubescensbush	Haptic properties, Rheology
Berry wax – From Rhus verniciflua berries (Varnish or lacquer tree)	Soft, Emulsion stabilization
Other waxes – Sunflower, Soy, Castor, Coconut, Almond…	Hydrophobic?, Oleophobic?

WAX PROPERTIES



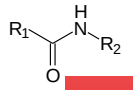
HDPE

- Abrasion resistance
- Antiblocking
- Slip



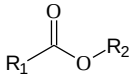
Paraffin

- Hydrophoby
- Antiblocking
- Slip



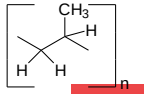
Amide

- Antiblocking
- Slip
- Soft touch



Carnauba Montan

- Scratch resistance
- Polishable



PP

- Antislip

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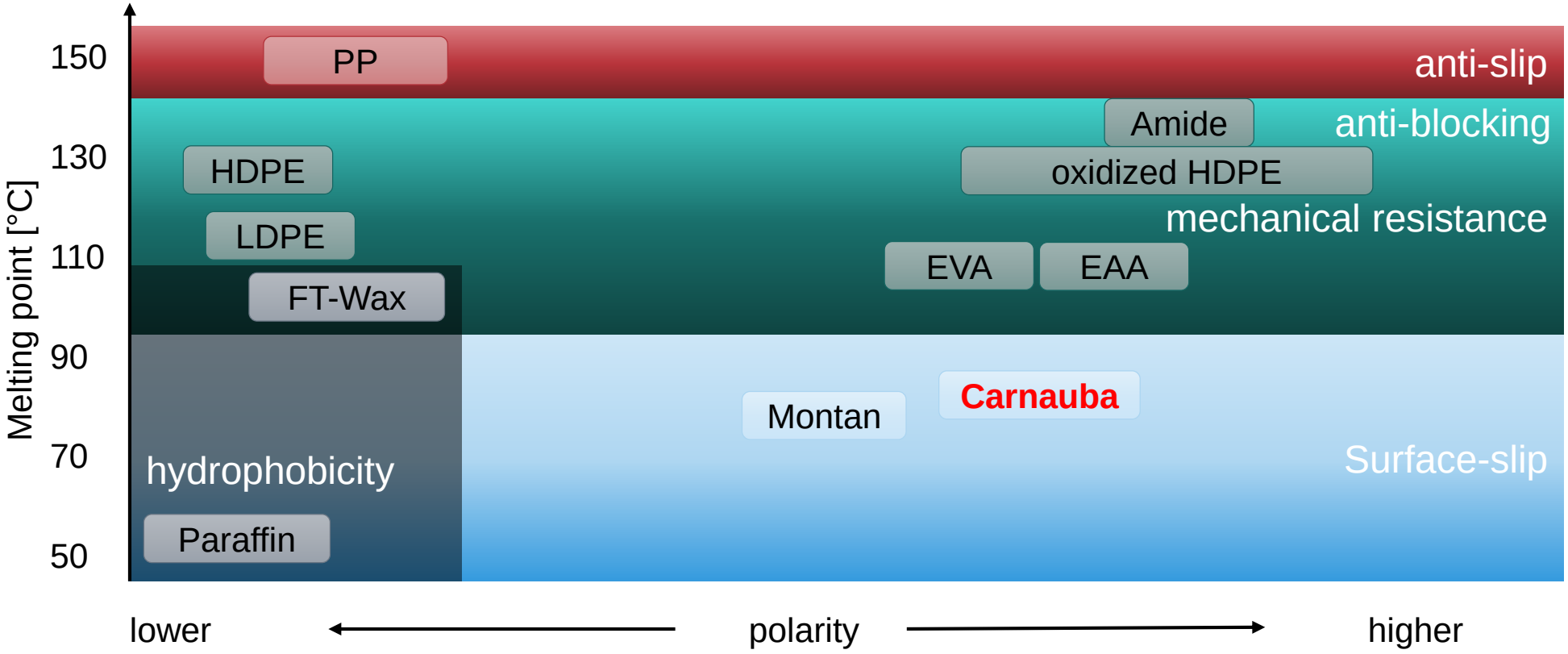
WAX CHARACTERISTICS



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FROM WAX TO ADDITIVE

- Raw waxes → granules, wax sheets, powder
- Not easy to incorporate into paint systems
- Waxes become wax additives
- Wax particles are finely distributed in a liquid phase →
  - Dispersion or emulsification
  - Stabilization by emulsifiers

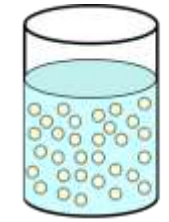
Emulsion Basics

Emulsion: A dispersion of one immiscible liquid in another, usually stabilized by a **surface active agent.**

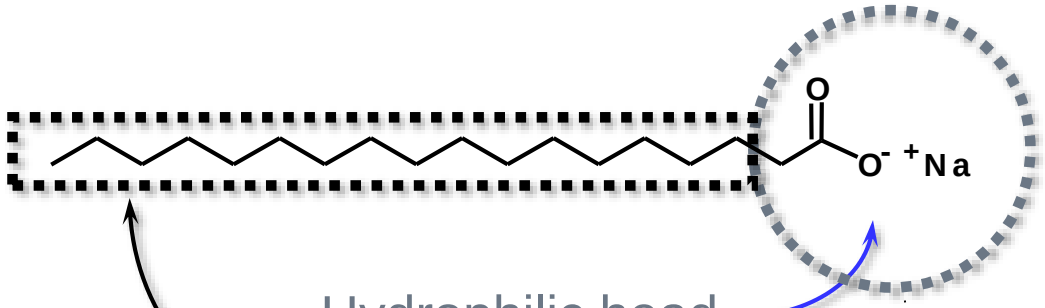
Surfactant: A substance which tends to reduce the surface tension of a liquid in which it is dissolved.

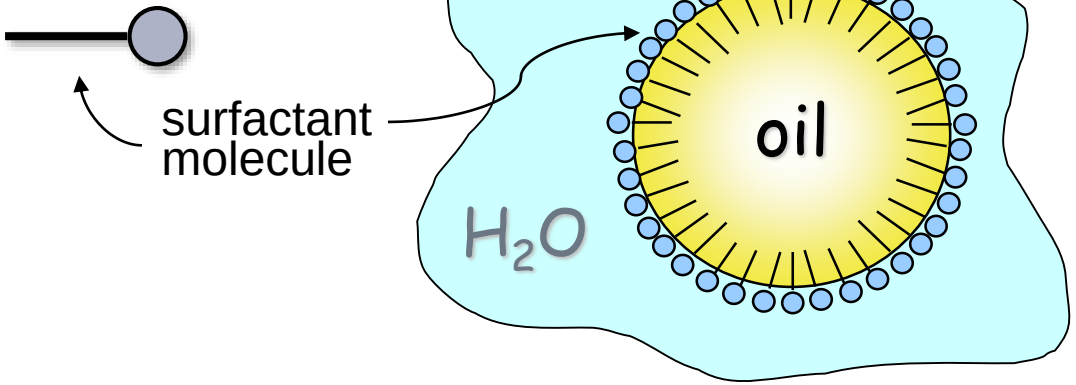
Surfactants are amphipathic compounds. Meaning they have and affinity for both water and oil:

There are three main types of surfactants: Nonionic, Cationic, and Anionic



Oil in Water Emulsion (O/W)





Oil-in-Water Emulsion (O/W)

Type of surfactant used imparts certain properties to the emulsion.

In case of multiple surfactant types, the emulsion takes its type from the "**more critical**" surfactant used (i.e., nonionic + anionic = anionic emulsion.)

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How Various Types of Emulsions are Made

High Shear Processing aka "Mechanical Emulsions"

Mix oil, H_2O, surfactant; subject mixture to high shear.

Mechanical emulsions is a broad term which captures various methods of high shear processing….. More to come!!

Emulsion Polymerization (EP):

Subject polymerizable monomer, H_2O, & surfactant to high shear; carry out polymerization of monomer. Useful with hydrophobic polymerizable monomers.

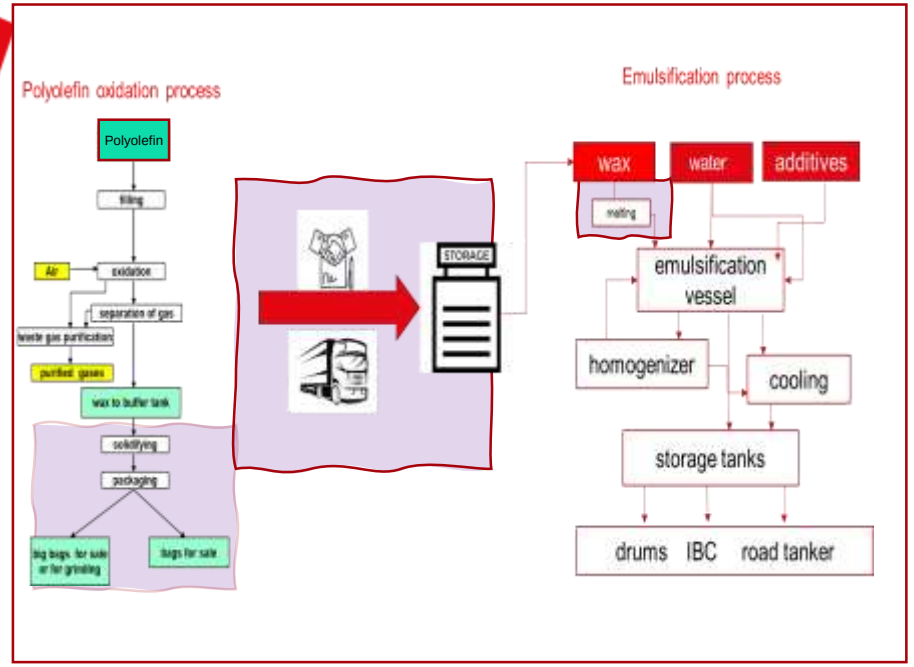
Think of each particle in this emulsion of being a micro-reactor

Microemulsion:

Emulsions < 100nm; spontaneously formed emulsions. Don't require shear forces.

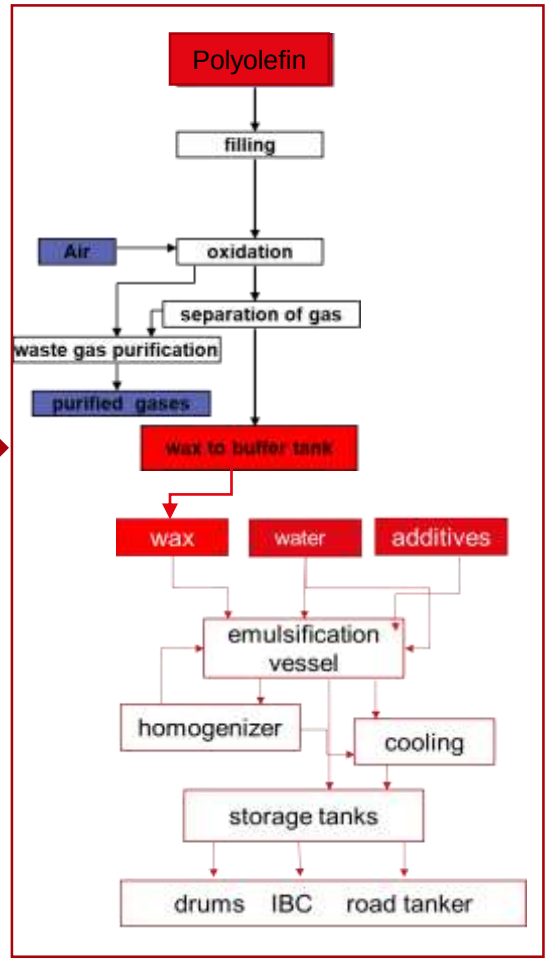
CHT STREAMLINED PROCESS WITH BACKWARD INTEGRATION OF THE WAX OXIDATION

Traditional way of making wax emulsions



Saving of process steps; save raw material source

Keim process



Wax Emulsion

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BARRIER COATING PRODUCTS

Product	Wax Type	Barrier effect			Rating
		Water	Oil/Grease	Water vapour	
Wax dispersion (40%, nonionic, pH 7.0)	Paraffin	✓		✓	★
Wax dispersion (40%, nonionic, pH 9.0)	Mod. Fischer-Tropsch	✓			🚀
Wax emulsion A (35%, nonionic / anionic, pH 9.5)	Natural blend	✓	✓		🍃
Wax emulsion B (35%, nonionic / anionic, pH 9.5)	Natural blend	✓	✓	✓	🍃
Wax dispersion (35%, nonionic, pH 4.5)	Carnauba	✓			🍃

- 🚀 **Price Value Best**
  - Product with best price-performance ratio
- ★ **Performance Best**
  - Product with best performance
- 🍃 **Eco Best**
  - Product with highest content of biobased material

REGULATORY STATUS

	Swiss Ordinance	FDA	Nestlé Guidance	Usable for SUPs	Free of MOSH / MOAH	Free of PFAS
Paraffin wax dispersion (40%, nonionic, pH 7.0)	List A	175.300 175.320 176.170 176.180	Yes	No	No MOAH MOSH content <14%	Yes
Mod. Fischer-Tropsch wax dispersion (40%, nonionic, pH 9.0)	List A	175.300 175.320 176.170 176.180	Yes	No	Yes	Yes
Natural blend Wax emulsion A (35%, nonionic / anionic, pH 9.5)	List A	175.300 175.320 176.170 176.180	Yes	Yes	Yes	Yes
Natural blend Wax emulsion B (35%, nonionic / anionic, pH 9.5)	List A	175.300 175.320 176.170 176.180	Yes	Yes	Yes	Yes
Carnauba wax dispersion (35%, nonionic, pH 4.5)	List A	175.300 175.320 176.170 176.180	Yes	Yes	Yes	Yes

- Mandatory information and limitations are documented in our FCM - Food Contact Material Statements (available upon request)

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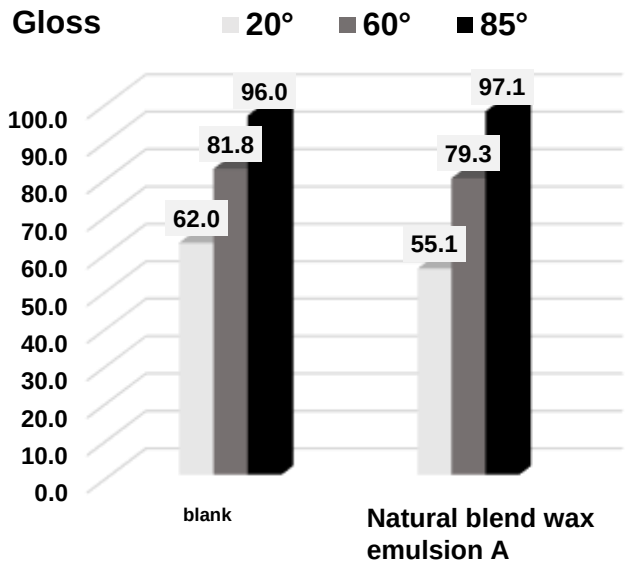
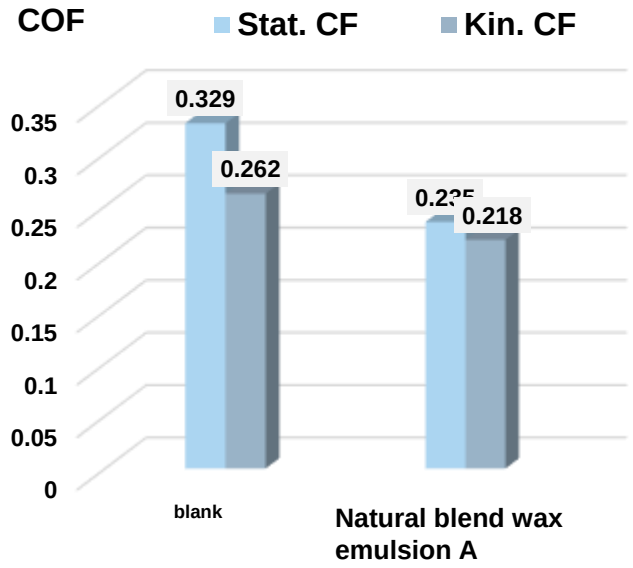
ULTRALUBE CT PRODUCTS
BASED ON RENEWABLE RESOURCES

product	wax type	biobased according ISO/IEC 17025:2017	Properties
Natural blend Wax emulsion A	Natural wax compound	100%	Sustainable replacement to paraffin and HDPE/paraffin in waterbased coatings
Natural blend Wax emulsion B	Natural wax compound	99%	Suitable for the formulation of barrier coatings on paper
Carnauba Wax dispersion A	Carnauba	94%	Excellent slip and scratch resistance for waterbased coatings
Carnauba Wax dispersion B	Carnauba	93%	Seed coating version fulfilling EPA regulatory requirement

NATURAL BLEND WAX EMULSION A





	contact angle	
Blank	70,7°	
Natural blend wax emulsion A	85,3°	

Natural blend wax emulsion A	
solids	35%
Ionic chararacter	nonionic/anionic
pH value	9.5
melting point	80°C

method	gloss / COF / contact angle
system	waterbased PU/acrylate dispersion
dosage	4% delivery form
conditions	60µm wet film thickness, drying

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BIO-BASED CARBON CONTENT - METHOD

- Radiocarbon (C14) reports
- Results reported as “% Biogenic Carbon” indicating the percentage carbon from “renewable” (biomass or animal by-product) sources versus petroleum (or otherwise fossil) sources .
- 100 % Biogenic Carbon indicates that a material is entirely sourced from plants or animal by-products
- 0 % Biogenic Carbon indicates that a material did not contain any carbon from plants or animal by-products.
- The analytical measurement is cited as “percent modern carbon (pMC)”. This is the percentage of C14 measured in the sample relative to a modern reference standard (NIST 4990C).
- The % Biogenic Carbon content is calculated from pMC by applying a small adjustment factor for C14 in carbon dioxide in air today. It is important to note is that all internationally recognized standards using C14 assume that the plant or biomass feedstocks were obtained from natural environments.
- Reported results are accredited to ISO/IEC 17025:2017 Testing Accreditation PJLA #59423 standards

BIO-BASED CARBON CONTENT – NATURAL WAX EMULSION A

Summary of Results - % Bio-based Carbon Content
EN 16640:2017 (AMS) Annex E Method B TC

Certificate Number: 54158365223013640 7

RESULT: 100 % Bio-based carbon as a fraction of total Carbon

% Bio-based Carbon Content EN 16640:2017 (AMS) Annex E Method B TC

CHT TECHNICAL CORE COMPETENCIES

COMPETITIVE ADVANTAGE

CHEMISTRY	RAW MATERIALS	SYNTHESIS	PROCESSING	FUNCTIONS
Wax	▶ Polyolefins ▶ Polyester ▶ **Natural Waxes**	▶ Oxidation	▶ **Emulsifying** ▶ **Formulating** ▶ Dispersing ▶ **Mixing** ▶ Milling	▶ **Surface Modification** ▶ **Hydrophobicity** ▶ Defoaming ▶ Wetting / Dispersing ▶ Rheology ▶ Film Formation
Silicone	▶ **PDMS** ▶ Siloxane Oligomers ▶ Silanes	▶ Equilibration ▶ Hydrosilylation ▶ Polycondensation		
Polysaccharide	▶ **Guar** ▶ **Xanthan** ▶ **Tamarind**	▶ Alkoxylation		
Synthetic Polymers[1)]	▶ Acrylics ▶ Isocyantes ▶ Polyols	▶ Polymerisation		

1) Polyacrylates, polyurethanes, polyester

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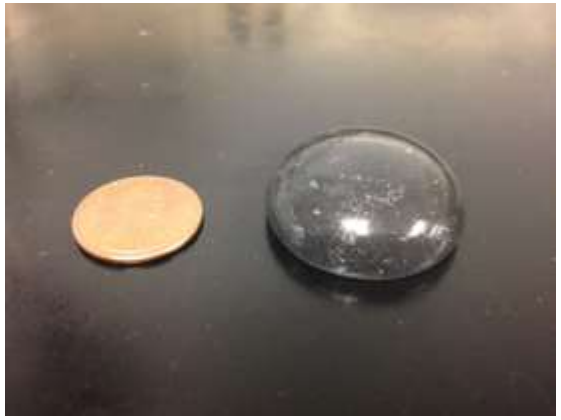
SILICONE GUM

initial



1 hour

24 hours

- Silicone gum - High MW linear polydimethylsiloxane (PDMS) having a
  - Viscosity on the order of 20M cP (20K Pa-sec)
  - DP of about 3,500 and higher
  - Mn ~260,000
- Usually SiOH terminated, also Me3SiO- (methyl) and H2C=CH- (vinyl) groups
- Silicone gum emulsions for slip additives usually are made of SiOH terminated polymer.

SILICONE GUM EMULSIONS – COATING ADVANTAGES

- Silicone gum emulsions find great utility as slip additives in coatings.

- Very high MW PDMS (eg- silicone gum) has become preferred slip additive in numerous coating applications.
  - Leather coatings – Also used to modify haptic properties including the hand (feel) of leather surfaces.
  - Printing Inks and OPVs

- Silicone gum emulsions provide block resistance to many coatings, including leather coatings, inks and overprint varnishes.

- Silicone gum emulsions are also used in specialized release applications.

SILICONE GUM EMULSIONS - PREPARATION

- Silicone gum is inherently difficult to emulsify due to the very high viscosity
- Silicone gum emulsification possible using specialized surfactants including certain SPE (silicone polyethers)
- Commercially available silicone gums contain cyclic silicones (can be bad for HS&E)
- Silicone gum preparation using EO/PO-based polymeric surfactants patented
- Stability when incorporated into water-based organic polymeric coatings is critical – need for additional hydrophilic process aid - Can contain residual aromatic solvent (bad for HS&E)

ADDITIONAL ROUTES TO SILICONE GUM EMULSIONS - INCREASING STABILITY AND SUSTAINABILITY

Methods for preparing silicone gum emulsions include the following:

1) **Reducing viscosity of gum by adding a solvent or diluent**
    1) Produces emulsions that provide slip properties to coatings
    2) Performance is generally lower than that of neat gum emulsions
    3) Solvents not good for HS&E
2) **In-situ emulsion polymerization** of reactive siloxanes
    1) Produces emulsions of polymers having viscosities comparable to silicone gum emulsions
    2) Excellent slip properties (low CoF, abrasion resistance, desirable hand)
    3) Emulsion stability is not as good as market leader's proprietary technology

CHT patented emulsification method for using an aminofunctional siloxane as a process aid:

Reduced cyclic silicone content

No residual aromatic solvent

Surfactants non-hazardous

SUMMARY

- Using sustainable raw materials is one key component of Sustainability
- Bio-Based Materials come from renewable domestic agricultural materials
- Natural, bio-based waxes can provide needed coatings properties
- Bio-sourced waxes can be used to make efective barrier coating additives
- New low cyclic silicone gum emulsions are more sustainabile
- Next Step - Carbon Footprint – A real measure of sustainability

Let‘s work together to:

Promote environmental and nature conservation

Use renewable, bio-based raw materials

Thank You For Your Attention

Questions?