

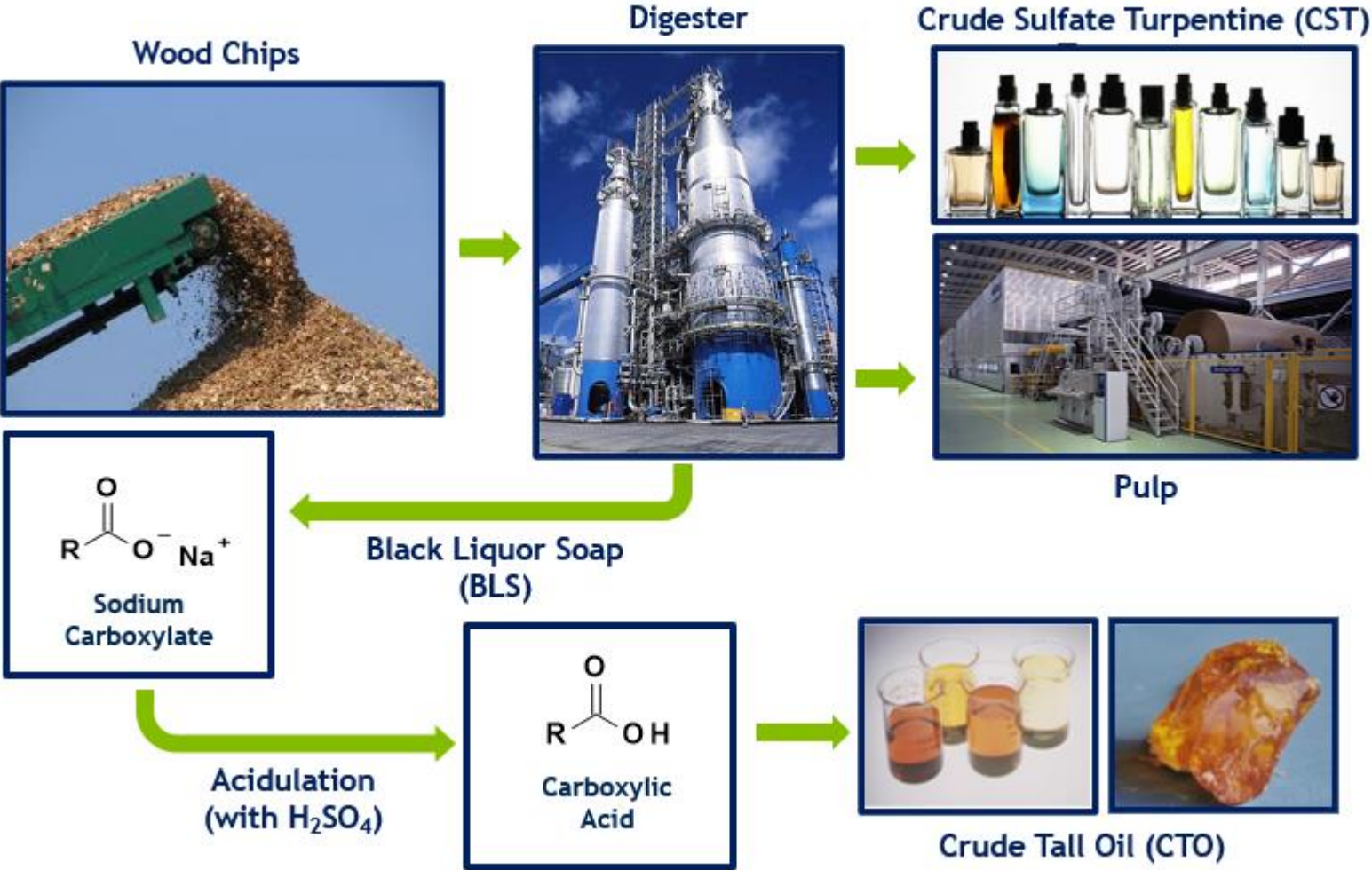
**Sustainable Solutions.
Endless Innovation.™**

KRATON™

**Biobased Oil for Lubricant
Formulations
EU Lube Expo
September 18, 2024**



Pine Chemicals: Kraft Pulping Process



Pine Chemicals: CTO streams

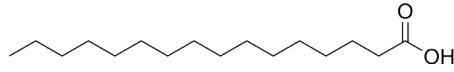
Crude Tall Oil Fractions



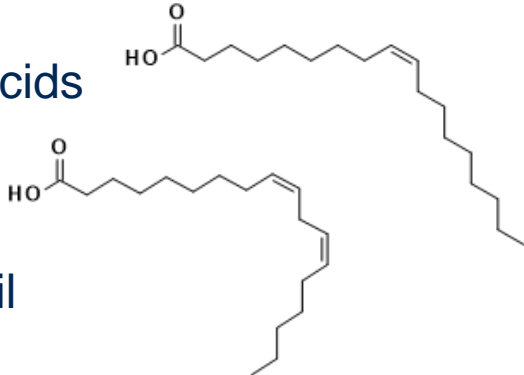
Crude Tall Oil (CTO)



Palmitic Heads

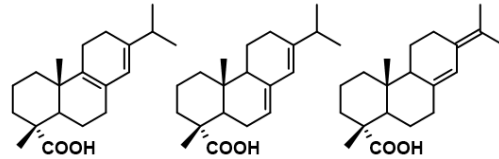


Tall Oil Fatty Acids (TOFA)



Distilled Tall Oil (DTO)

Rosin Acids (TOR)



Tall Oil Pitch



We Are Committed To Sustainability In Everything We Do

UPSTREAM

- + 6,000 Suppliers Worldwide
- Responsible Procurement Program



OUR OPERATIONS

- Health & Safety
- Climate Action
- Life Cycle Assessment (LCA)
- Energy, Waste And Water Management
- Global Ethics And Compliance Program
- Building A Diverse And Inclusive Culture



DOWNSTREAM

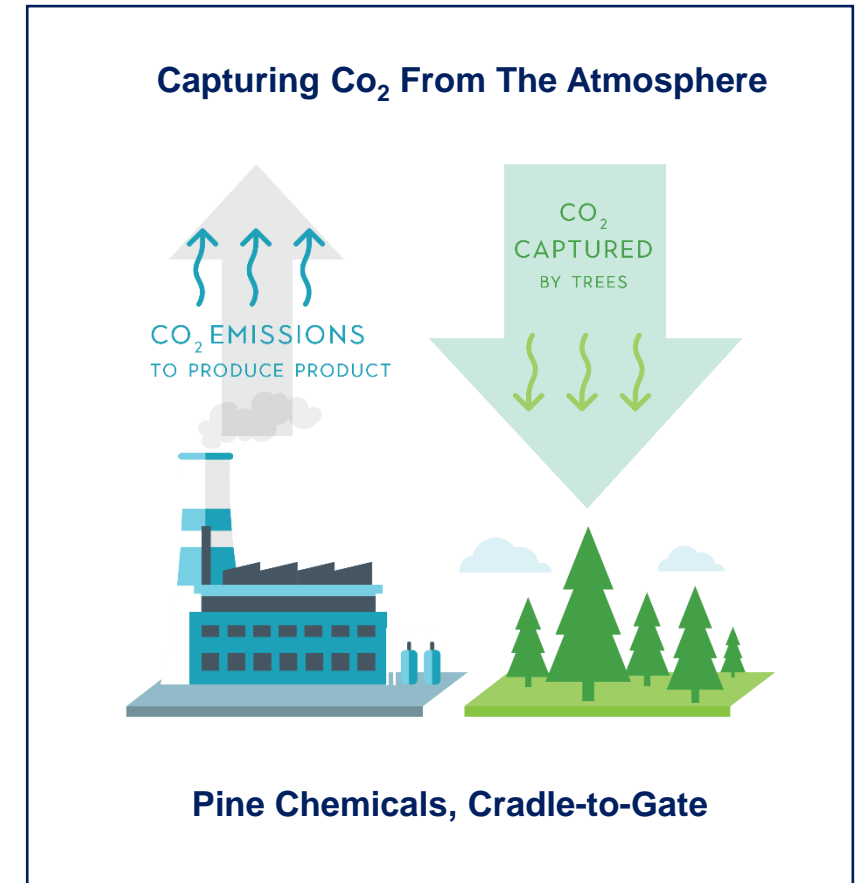
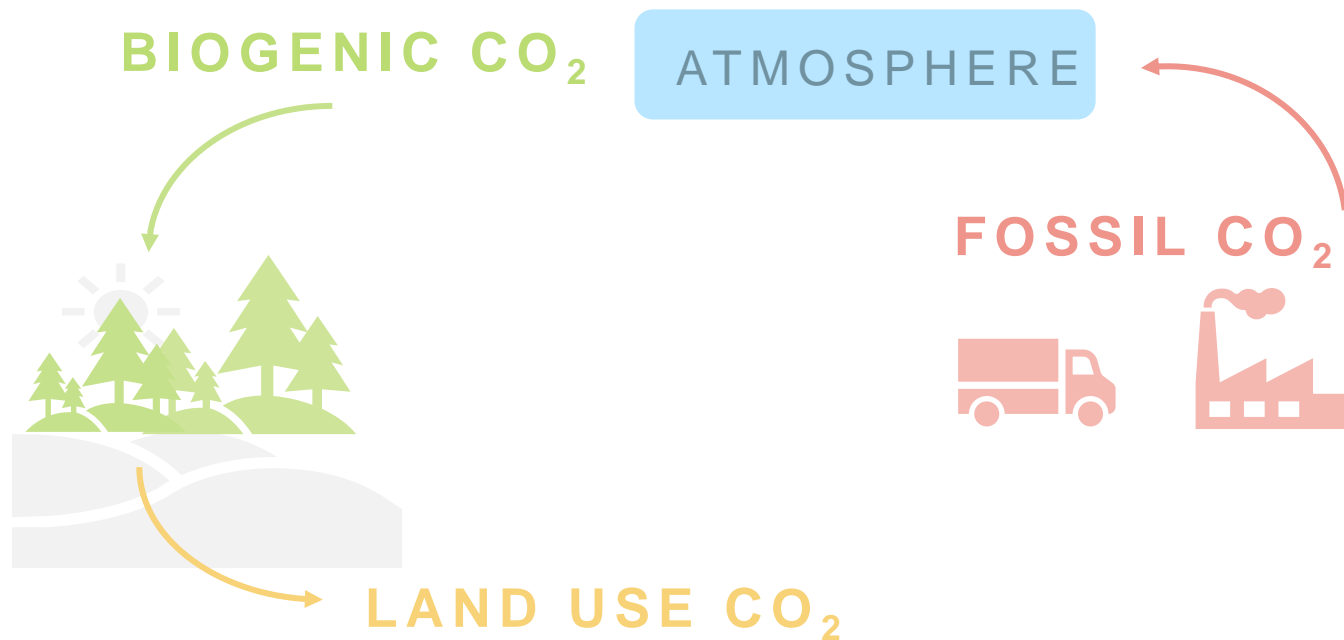
- Helping Our Customers To Advance The Biobased & Circular Economy
- LCA Support
- Product Stewardship
- Building Sustainable Communities



Global Warming Potential (GWP)

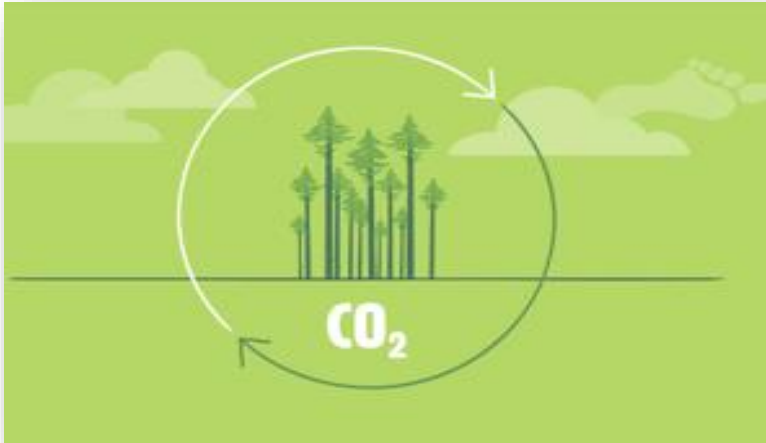
GWP Is Broken Down In:

- Fossil GWP
- Biogenic GWP
- Land Use GWP
- And Should Be Recorded Separately Until End-of-Life



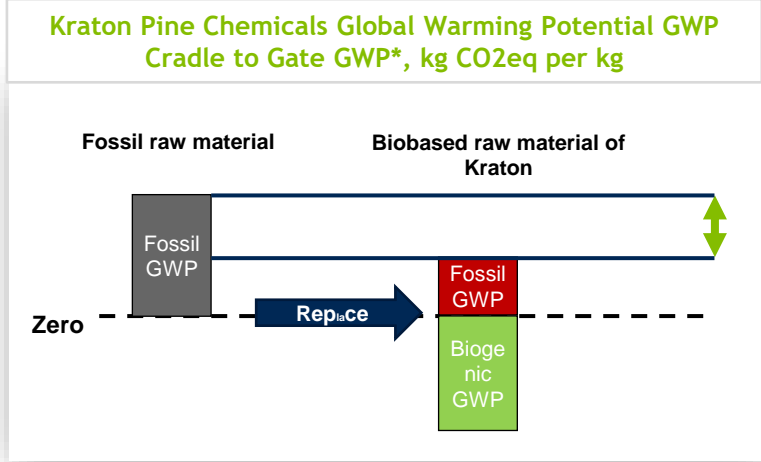
Biobased Hydrocarbon Oil: Commitment to Sustainability

Sustainable raw materials



- Responsibly managed forests
- Non-genetically modified trees
- Not competing with food crops
- No land use change

Low carbon footprint solutions



- Lower carbon footprint vs. fossil based alternatives**
- Opportunity for reducing “Scope 3” emissions



* Assuming the Fossil GWP of the Biobased material is lower than Fossil GWP of fossil based. The actual life cycle performance improvement that potentially can be achieved can only be concluded through an ISO certified process

Kraton 100% Biobased* Solutions for Lubricants

Diverse Portfolio Enhancing Performance Across Diverse Lubrication Applications.

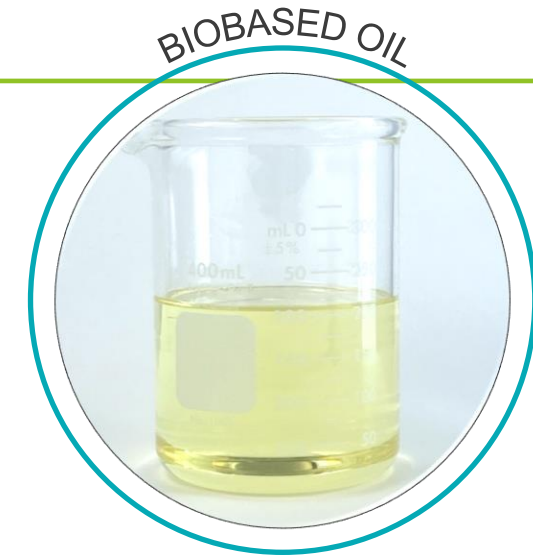
	Base Oil	Additive	Acid Functionality	Double Bond Functionality	Compatibilizer	Friction Modifier	Hydrolytic Stability
Biobased Hydrocarbon Oils	X	X			X	X	X
Fatty Acid	X	X	X	X		X	
Rosin Acid		X	X	X		X	
Dimer Acid	X	X	X	X		X	
Specialty Fatty Acid	X	X	X	X		X	
Terpenes		X		X			

- ▶ Building blocks for base oils and additives
- ▶ Wide range of products for various applications including industrial, metal working fluids and automotive lubricants.
- ▶ Biobased Hydrocarbon Oils are excellent base oils and additive compatibilizers for reduced processing temperature and time.
- ▶ Specialty Fatty Acid can improve emulsion stability of soluble and semi synthetic metal working fluids.

* SYLVASOLV Provisional Biobased Carbon Content Based on Radiocarbon (C14) USDA-Certified Lab Testing According to the USDA BioPreferred® Program. SYLFAT, SYLVAROS, UNIDYME, SYLVATAL, SYLVAPINE USDA Certified Biobased Products according to USDA BioPreferred® Program.

Biobased Hydrocarbon Oil Key Properties

Property	Method	Biobased Hydrocarbon Oil	Unit
Kinematic Viscosity (40°C)	ASTM D-445	22	cSt
Kinematic Viscosity (100°C)	ASTM D-445	3.8	cSt
Color	AQCM 002	2	Gardner
Aniline Point	ASTM D-611	13	°C
Acid Value	AQCM 001	3	mg KOH/g
Flash Point (COC)	ASTM D-92	142	°C
Pour Point	ASTM D-97	-24	°C
Electrical Conductivity	ASTM D-4308	0.60	pS/m
Thermal Conductivity, 75°C	ASTM D-7896	0.10	W/m-K



- 100% Biobased¹ Hydrocarbon Oil
- Lower Carbon Footprint
- High Solvency Power
- Not Flammable²
- Classified CARB LVP-VOC³

¹Provisional Biobased Carbon Content Based on Radiocarbon (C14) USDA-Certified Lab Testing According to the USDA BioPreferred® Program

²According to GHS criteria: flash point >93°C (199.4°F)

³The boiling point distribution of the product was assessed by SIM-Dist analysis performed according to EN-15199-2 and ASTM D2887 to classify low VOC based on EU Directive 2004/42/EC and CARB LVP-VOC.

Hydrolytic Stability of Biobased Hydrocarbon Oil Versus Next Best Alternatives

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Hydrolytic Stability Test (ASTM 2619)

	Acid number change mg KOH/g	Total acid acidity of water, mg KOH/g	Specimen loss, mg/cm ²	Appearance of specimen
Isopropyl oleate	0.08	15.2	-0.8	2e
Biobased Hydrocarbon Oil	-0.26	0.5	-0.2	1a
Group I	0	0.4	0	1b
Methyl oleate	-0.25	9.6	-0.6	2e

■ Biobased hydrocarbon oil demonstrates better hydrolytic stability vs isopropyl oleates and methyl oleates.

Biobased Hydrocarbon Oils in Lubricant Formulations

Applications:

- *Metal Working Fluids*
- *Automotive Oils*

Testing Protocol

- Formulation
 - *Soluble Oil*
- Tests
 - *Concentrate Stability*
 - *Emulsion Stability*
 - *Lubricity*
 - *Foaming Tendency*
 - *Corrosion Inhibition*

Soluble Oil Formulation

Component	Weight %
Complex Ester	77.93
Sulfonate	1.86
Distilled tall oil	10.64
Triethanolamine	2.66
Coupling Agent	6.91
Total	100

Performance of Base Oils in Soluble Oil Formulations

Performance Parameter	Test	Group I	Biobased Hydrocarbon Oil
Concentrate Stability	Visual	Slight haze	Clear
Emulsion Stability, Initial	Visual	Stable	Stable
Emulsion Stability	Centrifuge	Stable	Stable
pH initial	pH meter	7.7	7.7
pH after stability	pH meter	7.8	7.7
Particle Size (µm)	Beckman Coulter	179	129
60°C Stability	Visual	Stable at 28 days	Stable at 28 days
Lubricity	HFRR (mild), avg. film %/COF	91/0.076	91/0.089
Foaming	Shake test, mm initial/mm 1 min	0/0	0/0
Corrosion	Cast iron chip, % rust on filter paper	0	0

Biobased hydrocarbon oil demonstrates concentrate and emulsion stability as a base oil.

Summary

- Biobased hydrocarbon oils demonstrates better hydrolytic stability vs isopropyl oleates and methyl oleates.
- Biobased hydrocarbon oil is compatible in Group I and Group II base oils.
- 1:1 mixture of Group I, II, and the biobased hydrocarbon oil are all compatible with soybean oil and soybean methyl ester.
- The biobased hydrocarbon oil solubilizes up to 10% VLCCP whereas Group II and Group I oils did not.

Biobased Hydrocarbon Oil as Additive Compatibilizer in Engine Oil Formulations

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Testing Protocol

- Formulations
 - *Automotive*
- Tests
 - *Additive Compatibility*
 - *Base Oil Compatibility*
 - *Lubricity*
 - *Antiwear*
 - *Extreme Pressure*

Biobased Hydrocarbon Oil - Exceptional Solubility Power

Biobased Hydrocarbon Oil Compatibilized additives at 120°C within two hours.

Base Oil	Viscosity Modifier Solubilization		
	HSBC	PMMA	PIB
Biobased Hydrocarbon Oil	✓	✓	✓
Paraffinic Oil	✗	✓	✓
Naphthenic Oil	✗	✓	✓
PAO	✗	✗	✓
AN	✗	✓	✓

- Biobased Hydrocarbon Oil solubilizes a variety of additives faster and at lower temperature
- May enable reduced processing time, emissions and operational costs.

✗ - Insoluble up to 150°C and stirring three hours

Lawler Corrosivity and Oxidative Stability Test Results

	PAO/Ester	PAO/Ester/Biobased Hydrocarbon Oil	PAO/Biobased Hydrocarbon Oil	PAO/AN	PAO/AN/Biobased Hydrocarbon Oil
% Oil loss	0.40	0.36	0.01	0.67	0.39
%∇ KV40	-4.8	-4.5	9.0	43.0	-4.6
∇AN	4.8	0.2	2.3	0.2	-0.2
% Metal loss Al	0.0	0.0	0.1	0.0	0.1
% Metal loss mild steel	0.8	0.7	0.7	0.3	0.2
% Metal loss bronze	0.1	0.1	0.3	0.1	0.3
% Metal loss Mg	0.0	0.0	0.0	0.0	0.0

Biobased Hydrocarbon oil in Base oil in Engine oil Formulation

Component	PAO/Biobased Hydrocarbon Oil	PAO/Ester	PAO/Biobased Hydrocarbon Oil Ester	Group III/Biobased Hydrocarbon Oil Ester	Group III/Biobased Hydrocarbon Oil AN 5
PAO 4	70	70	70	0	0
Group III	0	0	0	70	70
Ester	0	15	7.5	7.5	0
AN 5	0	0	0	0	7.5
Biobased Hydrocarbon Oil	15	0	7.5	7.5	7.5
Additive package	10	10	10	10	10
5% VII in Biobased Hydrocarbon Oil	5	5	5	5	5
Total	100	100	100	100	100
Appearance	Clear	Clear	Clear	Clear	Clear
Acid number (mg KOH/g)	0.92	0.7	0.74	0.62	0.51
Viscosity index	143.9	157.7	152.2	149	145.4

Biobased hydrocarbon oil demonstrates excellent compatibility with various base oils in fully formulated engine oils.

Lubricity testing of Engine oil formulations with Hydrocarbon oil

Lubricity HFRR (ASTM 6079)	PAO/Ester	PAO/Ester/ Biobased Hydrocarbon Oil	PAO/ Biobased Hydrocarbon Oil	PAO/AN	PAO/AN/ Biobased Hydrocarbon Oil
Film, %	94	97	99	99	99
Coefficient of friction	0.117	0.118	0.118	0.114	0.118
Wear scar diameter, μm	148	141	148	160	153.5

Lubricity-Pin & Vee Block (ASTM 2670/3233)	PAO/Ester	PAO/Ester / Biobased Hydrocarbon Oil	PAO/ Biobased Hydrocarbon Oil	PAO/AN	PAO/AN / Biobased Hydrocarbon Oil
Wear, μm	238	210	260	274	307
Coefficient of Friction	0.086	0.085	0.088	0.094	0.091
Direct load at failure, lb	1405	1048	1003	1053	1135

Biobased Hydrocarbon Oil in Potential Electric Vehicle Applications

Property	Biobased Hydrocarbon Oil 1	Biobased Hydrocarbon Oil 2	Group III	AN
Dielectric Constant	2.31	2.05	1.95	2.18
Power Factor at 25 °C	0.01	0.01	0.01	0.11
Power Factor at 100 °C	2.34	0.39	0.08	3.9
Thermal Conductivity, 75 °C, W/m-K	0.1	0.09	0.13	0.13
Thermal Diffusivity, 75 °C, mm ² /s	0.06	0.06	0.07	0.07
Volumetric Heat Capacity, 75 °C, MJ/m ³ -K	1.66	1.6	1.89	1.89
Electrical Conductivity, pS/m	0.6	0.6	0.2	3.7

Biobased Hydrocarbon Oil



- Exhibits excellent compatibility with various base stocks, esters, polyalphaolefin, and alkylated naphthalenes, for use as co-oil or compatibilizer additive
- Excellent solubilization of difficult-to-solubilize additives enabling less processing time at lower processing temperature.
- Has lower electrical conductivity compared to alkylated naphthalenes.
- 100% biobased* hydrocarbon oil derived from crude tall oil, a pine wood pulping by-product, from responsibly managed forests.

*Provisional biobased carbon content based on radiocarbon C14 test by USDA certified lab, according to USDA BioPreferred® program

THANK YOU

Contact Amanda Marquez for any questions

amanda.marquez@kraton.com

Visit our website

www.Kraton.com

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