

# Introducing DuPont™ Crastin® Non-Halogenated (FR68XNH1) Product Family for Electrical & Electronics

Presented by

Nainish B Sanghani – Global Marketing Manager, Electrical & Electronics

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DuPont Transportation & Industrial



# About the Presenter



## **Nainish B. Sanghani**

Global Strategic Marketing Leader, Electrical & Electronics, at DuPont Transportation & Industrial business, is responsible for driving innovation and global business development. In this position, he is focused on setting strategy and developing solutions for electrical and electronics markets, including consumer electronics, connectors, 5G networks, electrical components and wire & cable.

Since joining the company in 2005, Nainish has held several key positions in sales, business development, product line management, strategic marketing in India, Asia-Pacific and the USA.

Nainish graduated from the Saurashtra University, India with a Bachelor of Mechanical Engineering. He also holds Master of Business Administration from NMIMS, University of Mumbai, India.

# The Flow...

- Why We Are Here
- New DuPont and DuPont Transportation & Industrial (T&I) business
- Key Trends in Electrical & Electronics Market
- DuPont™ Crastin® FR68XNH1 Product Family and Target Applications
- Technical Data
- Collaboration with DuPont
- Q&A



# Why We Are Here

- Ongoing trends of lighter, thinner and smaller designs in electrical devices, enhanced safety & reliability, increasing need for standardization & certifications are creating new challenges & opportunities for designers & engineers in the electrical & electronics value chains.
- At DuPont, we have been focused on pushing limits in performance of materials. For e.g. improving comparative tracking index while balancing toughness, flow, color stability etc. in formulations having non-halogenated flame retardants and easier to process and mold.
- We are expanding our already well-known product portfolio of Crastin® , Zytel® and Zytel® HTN with non-halogenated flame retardant product grades.
- Today, **we are introducing Crastin® FR68XNH1 (PBT) family** that offers superior electrical and a good balance of mechanical & thermal properties for E&E applications.
- At DuPont, we work with our customers with three key principles – Communicate, Collaborate and Create and strive to deliver innovative and targeted solutions for them.



# **New DuPont and DuPont Transportation & Industrial (T&I)**



**Welcome to  
a new DuPont**

**We empower  
the world  
with essential  
innovations  
to thrive...**







**...by discovering  
and delivering  
results that  
matter.**

# Driving innovation for a diverse set of industries

**34,000+**  
Colleagues

**215**  
Manufacturing Sites

**70+**  
Countries

**10+**  
Global R&D Centers

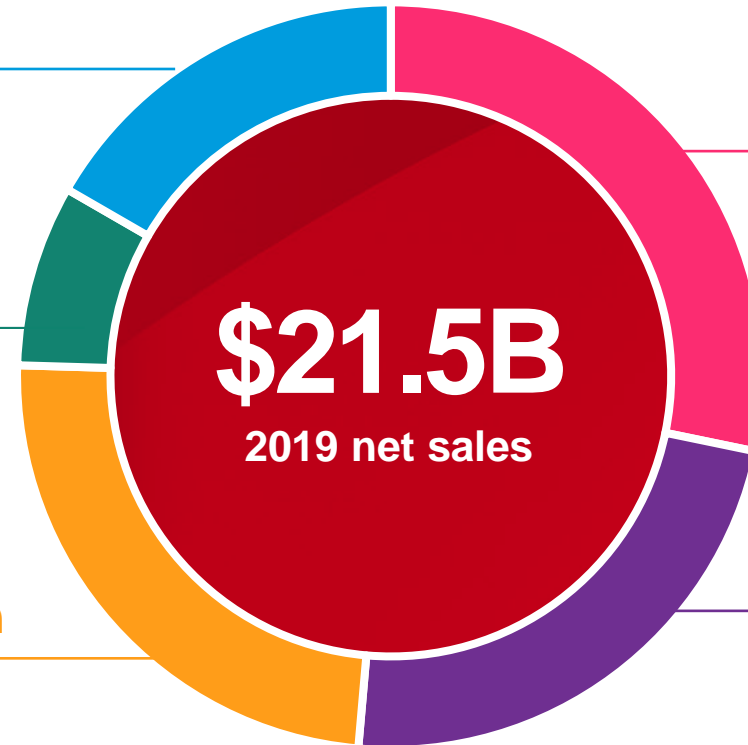
**Electronics  
& Imaging**  
**\$3.6B**

**Non-Core**  
**\$1.7B**

**Safety &  
Construction**  
**\$5.2B**

**Nutrition  
& Biosciences**  
**\$6.1B**

**Transportation  
& Industrial**  
**\$5.0B**





# Transportation & Industrial

Transforming industries and improving lives through material science



# At a glance: Transportation & Industrial



**\$5.0B**

2019 net sales

**~5,400**

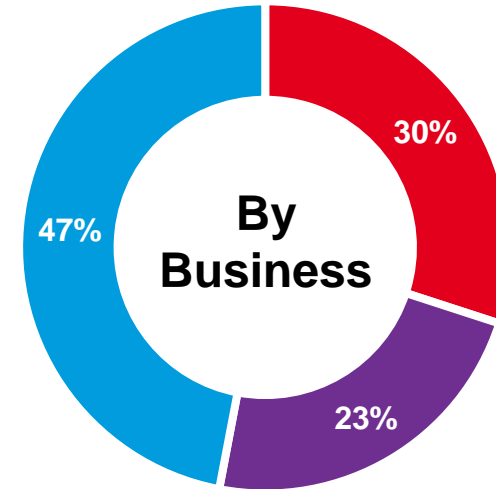
Colleagues

**39**

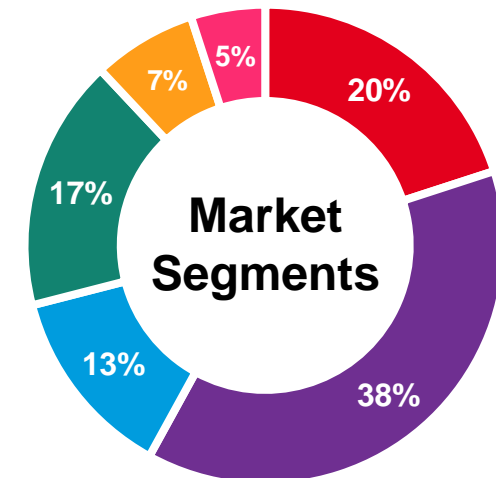
Manufacturing sites



## Net sales (2019):



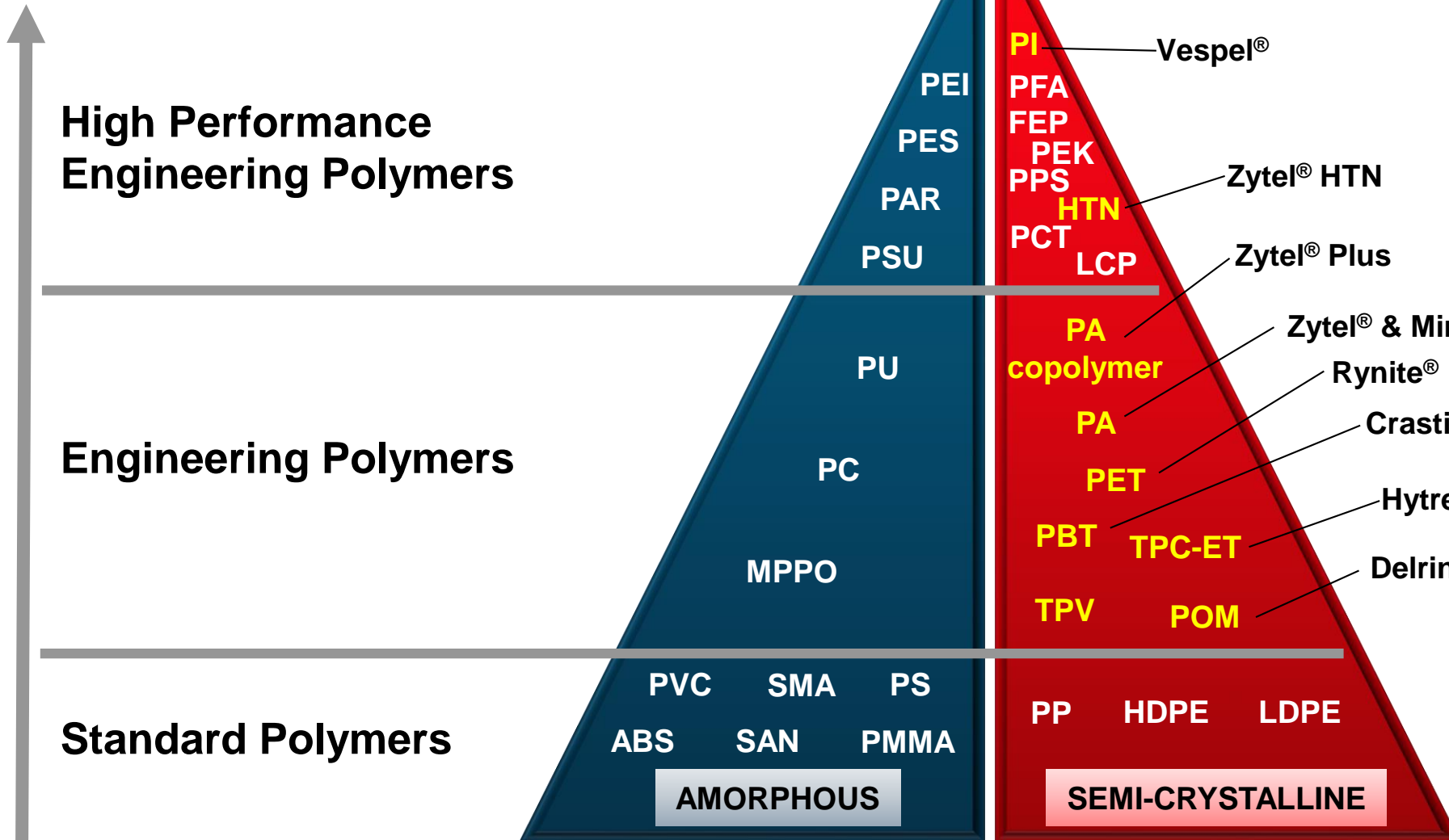
- Engineering
- Polymers
- Performance Resins
- Performance Solutions



- Auto-Core
- Advanced Mobility
- Electronics
- Industrial
- Consumer
- Healthcare

# DuPont Polymers Portfolio

Temperature / Price / Performance



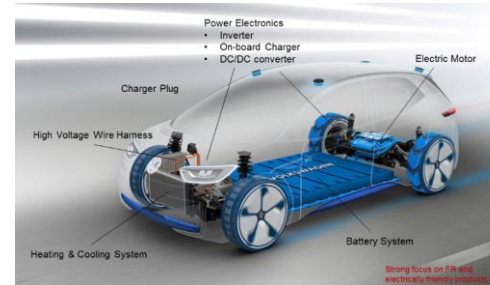
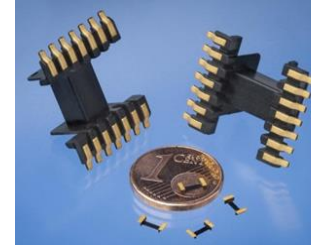
- + Vamac® Acrylic Rubber
- + Kalrez® FFKM Rubber
- + Si masterbatch
- + TPSiV®



# Key Trends in Electrical & Electronics Market

# Key Trends in Electrical & Electronics Market

- Miniaturization and Thin-Walling of Housings
- Higher in-use Performance and Harsh Environments
- Quest for New Mobility
- Need for Colors and Finishes
- Directives, Regulations and Certifications





# DuPont™ Crastin® FR68XNH1 Product Family



# Introducing Today – Crastin® FR68XNH1 Product Family

Crastin® FR68XNH1 represents a new generation of non-halogenated flame retardant Polybutylene Terephthalate (PBT) product that offers a good balance of mechanical properties together with industry leading high CTI, flammability at tight thicknesses, lower density, high flow and equivalent processing performance as halogenated PBT

## Naming Convention

Crastin® FR68XNH1 NC010

Flame Retardant  
Glass Reinforced Level  
Non-Halogenated

Color Codes

X → Glass Reinforced Level

0 → Un-reinforced

2 → 15%

4 → 25%

5 → 30%

NC010 – Natural Color

BK591 – Black Color

OR162 – Orange Color

GY090 – Gray Color\*

WT173 – White Color\*



\* Development grades

# Crastin® FR684NH1 – Key Characteristics

25% Glass Reinforced, Flame Retardant, Non-halogenated, Polybutylene Terephthalate Resin, PBT-GF25FR(40)

- UL94-V0 @ 0.75mm – **NC, GY, BK, WT**; 0.4mm – **OR** (Orange)
- Improved heat ageing: RTI/ 0.75-3.0 mm: Electrical (130°C), Impact (125°C), Strength (140°C)
- Good balance of Stiffness/Elongation (T. Mod > 9000MPa, Eb-2.5%)
- Glow Wire:
  - GWFI (@1mm) (IEC 60695-2-12) 960 °C at 0.75 mm/t
  - GWIT (@1mm) (IEC 60695-2-13) 750 °C at 0.75 mm/t
- **Excellent electrical properties**
  - CTI (IEC): 600V, PLC:0
- Higher Flow performance vs halogenated grades
- Equivalent processing performance in comparison to halogenated grades
- Low mold deposit and low melt corrosivity
- Low density vs halogenated PBT (approx. -10%)
- **Excellent Color Stability**

## Technical Data Sheet

Crastin® FR684NH1 NC010 (PRELIMINARY) THERMOPLASTIC POLYESTER RESIN	Crastin® FR684NH1 BK591 (PRELIMINARY) THERMOPLASTIC POLYESTER RESIN
<p><b>Product Information</b></p> <p>Resin identification: 88T-G20FR68B ISO 1044 Part Number Code: 48T-G20FR68B ISO 1044</p> <p><b>Rheological properties</b></p> <p>Moulding shrinkage, parallel: 0.3 % ISO 2844-1:2017 Moulding shrinkage, normal: 0.3 % ISO 2844-1:2017 Flow length: 360 mm ISO 2844-1:2017 Flow length - w/RTI(40)class: 150 mm Flow length - w/RTI(40)class: 2 mm</p> <p><b>Typical mechanical properties</b></p> <p>Tensile Modulus: 9600 MPa ISO 527-2:0 Tensile strength: 90 MPa ISO 527-2:0 Stress at break: 2.2 % ISO 527-2:0 Charpy notched impact strength, 23°C: 75 kJ/m² ISO 179:W4 Rebound ratio: 0.88 -</p> <p><b>Thermal properties</b></p> <p>Melting temperature, 10°C/min: 255 °C ISO 11357-2:0 Softening point, 10°C/min: 255 °C ISO 11357-2:0 Temp. of deflection under load, 1.8 MPa: 205 °C ISO 75-2:0 Recrystallization: 205 °C ISO 11357-2:0 CTE, Parallel, 40-100°C: 20 1/K ISO 11357-2:0 CTE, Parallel, 100-150°C: 20 1/K ISO 11357-2:0 CTE, Parallel, 150-200°C: 20 1/K ISO 11357-2:0 CTE, Normal, 40-100°C: 20 1/K ISO 11357-2:0 CTE, Normal, 100-150°C: 20 1/K ISO 11357-2:0 CTE, Normal, 150-200°C: 20 1/K ISO 11357-2:0 Coeff. of linear thermal expansion, Normal, 23-100°C: 10 1/K ISO 11357-2:0 RTI electrical, 100h: 600 V IEC 60112 RTI electrical, 100h: 600 V IEC 60112</p>	<p><b>Product Information</b></p> <p>Resin identification: 88T-G20FR68B ISO 1044 Part Number Code: 48T-G20FR68B ISO 1044</p> <p><b>Rheological properties</b></p> <p>Moulding shrinkage, parallel: 0.3 % ISO 2844-1:2017 Moulding shrinkage, normal: 0.3 % ISO 2844-1:2017</p> <p><b>Typical mechanical properties</b></p> <p>Tensile Modulus: 9600 MPa ISO 527-2:0 Tensile strength: 90 MPa ISO 527-2:0 Stress at break: 2.2 % ISO 527-2:0 Charpy notched impact strength, 23°C: 75 kJ/m² ISO 179:W4 Rebound ratio: 0.88 -</p> <p><b>Thermal properties</b></p> <p>Melting temperature, 10°C/min: 255 °C ISO 11357-2:0 Softening point, 10°C/min: 255 °C ISO 11357-2:0 Temp. of deflection under load, 1.8 MPa: 205 °C ISO 75-2:0 Recrystallization: 205 °C ISO 11357-2:0 CTE, Parallel, 40-100°C: 20 1/K ISO 11357-2:0 CTE, Parallel, 100-150°C: 20 1/K ISO 11357-2:0 CTE, Parallel, 150-200°C: 20 1/K ISO 11357-2:0 CTE, Normal, 40-100°C: 20 1/K ISO 11357-2:0 CTE, Normal, 100-150°C: 20 1/K ISO 11357-2:0 CTE, Normal, 150-200°C: 20 1/K ISO 11357-2:0 Coeff. of linear thermal expansion, Normal, 23-100°C: 10 1/K ISO 11357-2:0 RTI electrical, 100h: 600 V IEC 60112 RTI electrical, 100h: 600 V IEC 60112</p>
<p><b>Crastin® FR684NH1 OR162 (PRELIMINARY) THERMOPLASTIC POLYESTER RESIN</b></p> <p><b>Product Information</b></p> <p>Resin identification: 88T-G20FR68B ISO 1044 Part Number Code: 48T-G20FR68B ISO 1044</p> <p><b>Rheological properties</b></p> <p>Moulding shrinkage, parallel: 0.3 % ISO 2844-1:2017 Moulding shrinkage, normal: 0.3 % ISO 2844-1:2017</p> <p><b>Typical mechanical properties</b></p> <p>Tensile Modulus: 9600 MPa ISO 527-2:0 Tensile strength: 90 MPa ISO 527-2:0 Stress at break: 2.2 % ISO 527-2:0 Charpy notched impact strength, 23°C: 75 kJ/m² ISO 179:W4 Rebound ratio: 0.88 -</p> <p><b>Thermal properties</b></p> <p>Melting temperature, 10°C/min: 255 °C ISO 11357-2:0 Softening point, 10°C/min: 255 °C ISO 11357-2:0 Temp. of deflection under load, 1.8 MPa: 205 °C ISO 75-2:0 Recrystallization: 205 °C ISO 11357-2:0 CTE, Parallel, 40-100°C: 20 1/K ISO 11357-2:0 CTE, Parallel, 100-150°C: 20 1/K ISO 11357-2:0 CTE, Parallel, 150-200°C: 20 1/K ISO 11357-2:0 CTE, Normal, 40-100°C: 20 1/K ISO 11357-2:0 CTE, Normal, 100-150°C: 20 1/K ISO 11357-2:0 CTE, Normal, 150-200°C: 20 1/K ISO 11357-2:0 Coeff. of linear thermal expansion, Normal, 23-100°C: 10 1/K ISO 11357-2:0 RTI electrical, 100h: 600 V IEC 60112 RTI electrical, 100h: 600 V IEC 60112</p>	<p><b>Crastin® FR684NH1 GY090 (PRELIMINARY) THERMOPLASTIC POLYESTER RESIN</b></p> <p><b>Product Information</b></p> <p>Resin identification: 88T-G20FR68B ISO 1044 Part Number Code: 48T-G20FR68B ISO 1044</p> <p><b>Rheological properties</b></p> <p>Moulding shrinkage, parallel: 0.3 % ISO 2844-1:2017 Moulding shrinkage, normal: 0.3 % ISO 2844-1:2017</p> <p><b>Typical mechanical properties</b></p> <p>Tensile Modulus: 9600 MPa ISO 527-2:0 Tensile strength: 90 MPa ISO 527-2:0 Stress at break: 2.2 % ISO 527-2:0 Charpy notched impact strength, 23°C: 75 kJ/m² ISO 179:W4 Rebound ratio: 0.88 -</p> <p><b>Thermal properties</b></p> <p>Melting temperature, 10°C/min: 255 °C ISO 11357-2:0 Softening point, 10°C/min: 255 °C ISO 11357-2:0 Temp. of deflection under load, 1.8 MPa: 205 °C ISO 75-2:0 Recrystallization: 205 °C ISO 11357-2:0 CTE, Parallel, 40-100°C: 20 1/K ISO 11357-2:0 CTE, Parallel, 100-150°C: 20 1/K ISO 11357-2:0 CTE, Parallel, 150-200°C: 20 1/K ISO 11357-2:0 CTE, Normal, 40-100°C: 20 1/K ISO 11357-2:0 CTE, Normal, 100-150°C: 20 1/K ISO 11357-2:0 CTE, Normal, 150-200°C: 20 1/K ISO 11357-2:0 Coeff. of linear thermal expansion, Normal, 23-100°C: 10 1/K ISO 11357-2:0 RTI electrical, 100h: 600 V IEC 60112 RTI electrical, 100h: 600 V IEC 60112</p>

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# Crastin® FR684NH1 - Key Features & Benefits

Industry Requirements	Benefits	Characteristics
<ul style="list-style-type: none"> <li>Regulation Compliance</li> </ul>	<ul style="list-style-type: none"> <li>Meets RoHS, REACH, WEEE</li> </ul>	<ul style="list-style-type: none"> <li>Non-halogenated flame retardant formulation</li> </ul>
<ul style="list-style-type: none"> <li>Design freedom and cost reduction</li> </ul>	<ul style="list-style-type: none"> <li>Miniaturization, Complex shapes with thinner walls, allowing high design flexibility and size reduction</li> </ul>	<ul style="list-style-type: none"> <li>High CTI (600V)</li> <li>High flow (+ 40% vs halogenated)</li> <li>High RTI Electrical (130°C)</li> <li>Lower density (-10% vs halogenated resin)</li> </ul>
<ul style="list-style-type: none"> <li>Improved Quality &amp; Productivity</li> </ul>	<ul style="list-style-type: none"> <li>Reduced Maintenance</li> <li>Better color fastness</li> <li>Easy identification &amp; tracking</li> </ul>	<ul style="list-style-type: none"> <li>Low mold deposit and low melt corrosivity.</li> <li>Color stability under harsh environment</li> <li>Laser Markable in black and Orange color</li> <li>Light in natural color</li> </ul>
<ul style="list-style-type: none"> <li>Long term performance under higher temperatures</li> </ul>	<ul style="list-style-type: none"> <li>Long term reliability and safety</li> </ul>	<ul style="list-style-type: none"> <li>RTI/ 0.75-3.0 mm: Electrical (130°C), Impact (125°C), Strength (140°C)</li> </ul>
<ul style="list-style-type: none"> <li>Meet increasingly stringent safety standards</li> </ul>	<ul style="list-style-type: none"> <li>Compliance with electrical industry standards, i.e. UL, IEC</li> </ul>	<ul style="list-style-type: none"> <li>CTI (600V acc. IEC60112 &amp; UL746A)</li> <li>V-0 rating (0.4-3.00 mm)</li> <li>Electric strength (1mm) (IEC 60243-1) 44 kV/mm</li> <li>GWFI (0.75-3.00mm) (IEC 60695-2-12) 960 °C</li> </ul>

# Crastin® FR684NH1 – UL yellow card

## FR684NH1

Polybutylene Terephthalate (PBT), glass reinforced, flame retardant "Crastin", furnished as pellets

<u>Color</u>	<u>Min. Thk</u> (mm)	<u>Flame</u> <u>Class</u>	<u>HWI</u>	<u>HAI</u>	<u>RTI</u> <u>Elec</u>	<u>RTI</u> <u>Imp</u>	<u>RTI</u> <u>Str</u>
NC, GY, BK, WT	0.75	V-0	4	0	130	125	140
	1.5	V-0	1	0	130	125	140
	3.0	V-0	0	0	130	125	140

Comparative Tracking Index (CTI): 0	Inclined Plane Tracking (IPT) kV: -
Dielectric Strength (kV/mm): -	Volume Resistivity (10 <sup>x</sup> ohm-cm): -
High-Voltage Arc Tracking Rate (HVTR): -	Surface Resistivity (10 <sup>x</sup> ohms/square): -
Dimensional Stability (%): -	High Volt, Low Current Arc Resis (D495): -

Glow-Wire Flammability (GWFI)	IEC 60695-2-12	°C	0.75	960
			1.5	960
			3.0	960
Glow-Wire Ignition (GWIT)	IEC 60695-2-13	°C	0.75	750
			1.5	750
			3.0	800

## FR684NH1 OR

Polybutylene Terephthalate (PBT), glass reinforced, flame retardant "Crastin", furnished as pellets

<u>Color</u>	<u>Min. Thk</u> (mm)	<u>Flame</u> <u>Class</u>	<u>HWI</u>	<u>HAI</u>	<u>RTI</u> <u>Elec</u>	<u>RTI</u> <u>Imp</u>	<u>RTI</u> <u>Str</u>
OR	0.4	V-0	-	-	75	75	75
	0.75	V-0	4	-	75	75	75
	3.0	V-0	1	-	75	75	75

Comparative Tracking Index (CTI): 0	Inclined Plane Tracking (IPT) kV: -
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# Crastin® FR684NH1 in Fully Compounded Colors

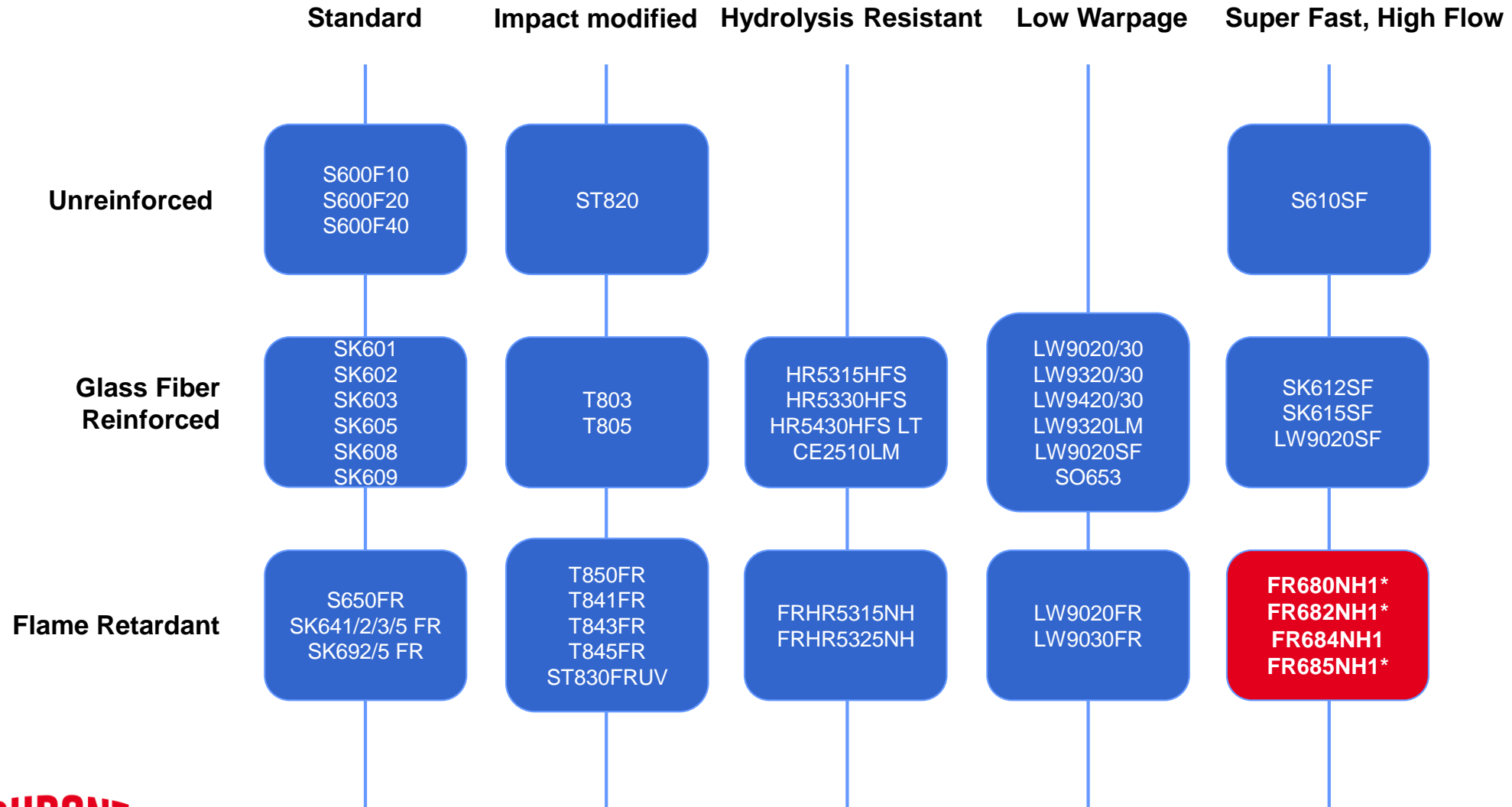
Property		OR162	NC010	BK591	GY090*	WT173*
Resin Identification ISO 1043		PBT-GF25FR(40)				
Tensile Modulus ISO 527-1/-2	MPa	9500	9400	9200	9400	8400
Strain at break ISO 527-1/-2	%	2.5	2.5	2.3	2.3	2.2
Charpy Notched Impact Strength, 23°C ISO 179/1eA	KJ/m <sup>2</sup>	7.4	7.5	7.0	7.0	4.2
Flammability IEC 60695-11-10		V-0 @ 0.4mm	V-0 @ 0.75mm	V-0 @ 0.75mm	V-0 @ 0.75mm	V-0 @ 0.75mm
Glow Wire Flammability Index, 0.75mm IEC 60695-2-12	°C	-	960	960	960	960
Glow Wire Ignition Temperature, 0.75mm IEC 60695-2-13	°C	-	750	750	750	750
Comparative Tracking Index IEC 60112		600	600	600	600	600
Electric Strength	kV/mm	-	42	42(DS)		



\* Development grades

# Crastin® Product Portfolio & Crastin® FR68XNH1

Main product code shown as example for the most typical grade. Many others are available. Not all families shown



\* Development grades

# Target Applications for Crastin® FR68XNH1



High Voltage Automotive Connectors & Battery



Power Charging Connectors



Plug Connectors



Coil Forms



Motor parts



Industrial Breakers



Solenoids, Switches & Relays

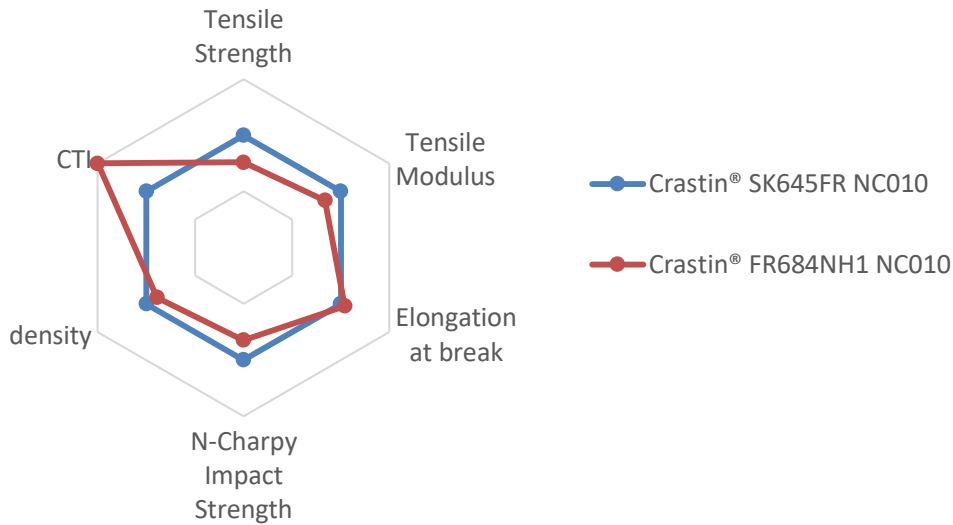
# Technical Data



# Property Summary

## Crastin® FR684NH1 vs. Crastin® halogenated FR grade

Comparison vs. halogenated FR PBT



### Crastin® Non Halogenated version provides

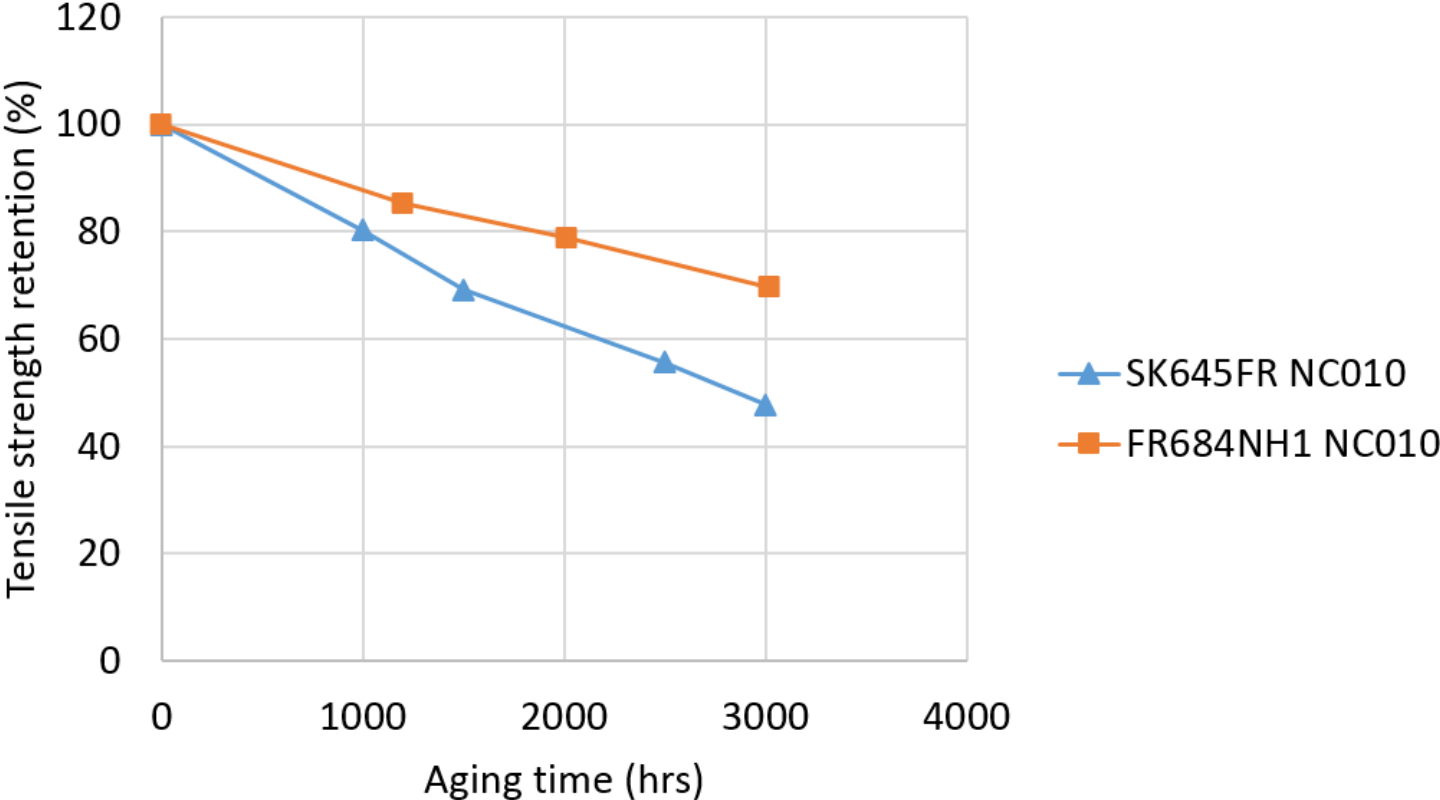
- lower density
- slightly lower mechanical properties, but keeping elongation at break.
- High CTI (600V) vs (250V Halogenated)

	Tensile Strength (MPa)	Tensile Modulus (MPa)	Elongation at break (%)	N-Charpy Impact Strength (kJ/m <sup>2</sup> )	Density (g/cm <sup>3</sup> )	CTI (V)
Crastin® SK645FR NC010	125	11200	2.4	9.1	1.71	250
Crastin® FR684NH1 NC010	95	9400	2.5	7.5	1.52	600



# Heat aging performance at 180°C

Crastin® FR684NH1 vs. Crastin® halogenated FR grade



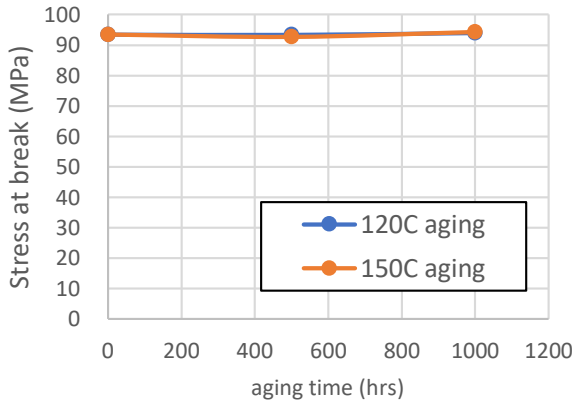
○ Higher retention than Crastin® halogenated FR grade



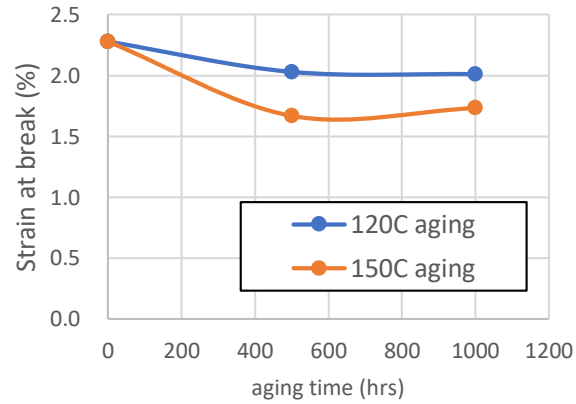
# Heat aging performance at 120°C and 150°C

Crastin® FR684NH1

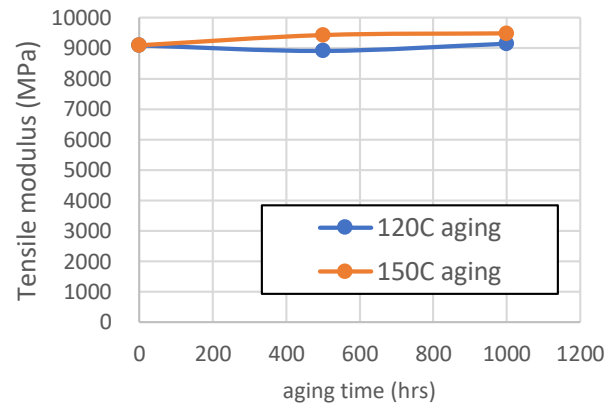
Stress at break after heat aging



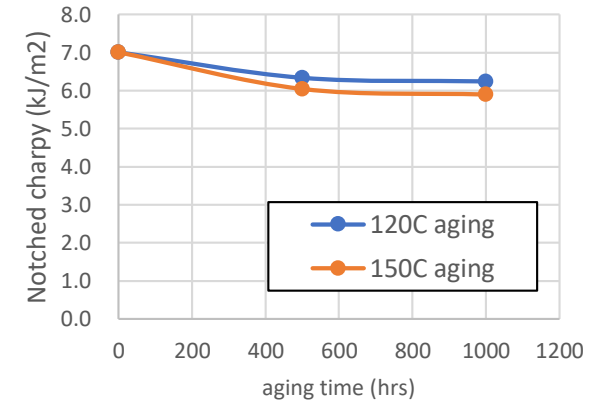
Strain at break after heat aging



Tensile modulus after heat aging



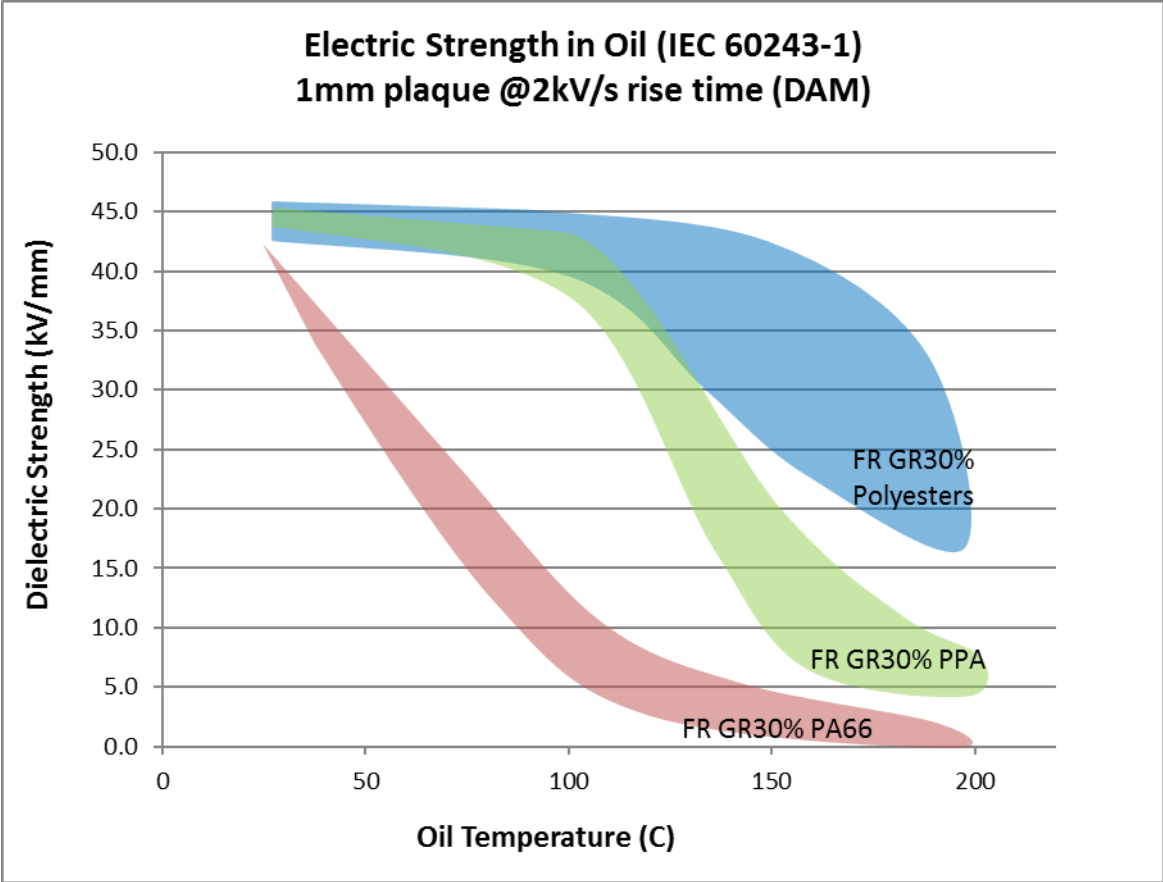
Notched charpy after heat aging



- **Strain at break keeps 80% of initial after 1000hrs at 150°C**
- **Notched charpy impact strength keeps 85% of initial after 1000hrs at 150°C**

# Electric Strength at Elevated Temperature

General comparison between polymer family

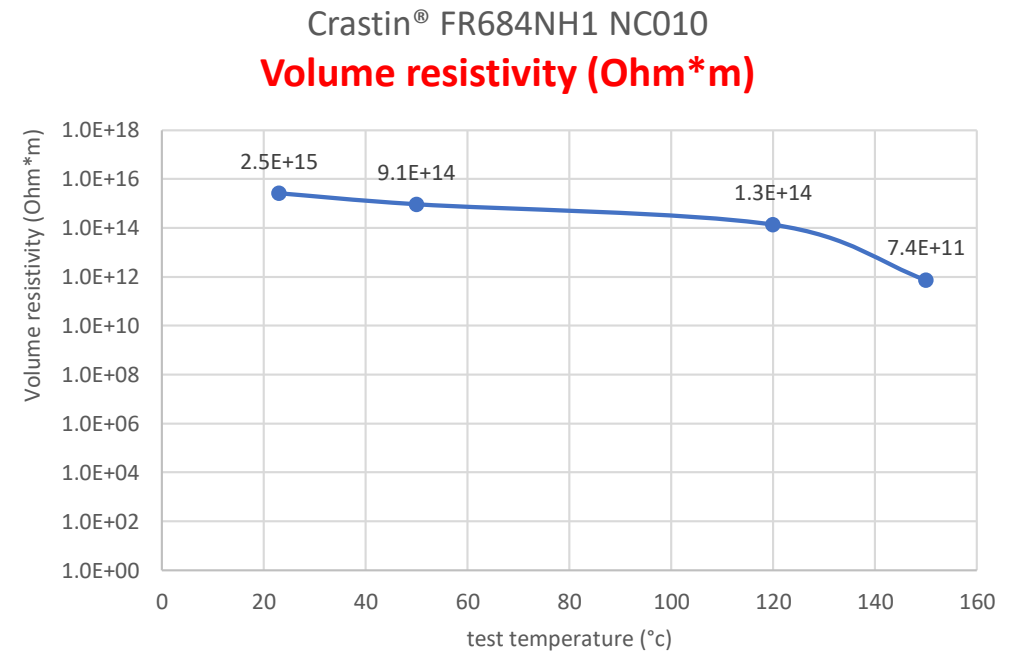
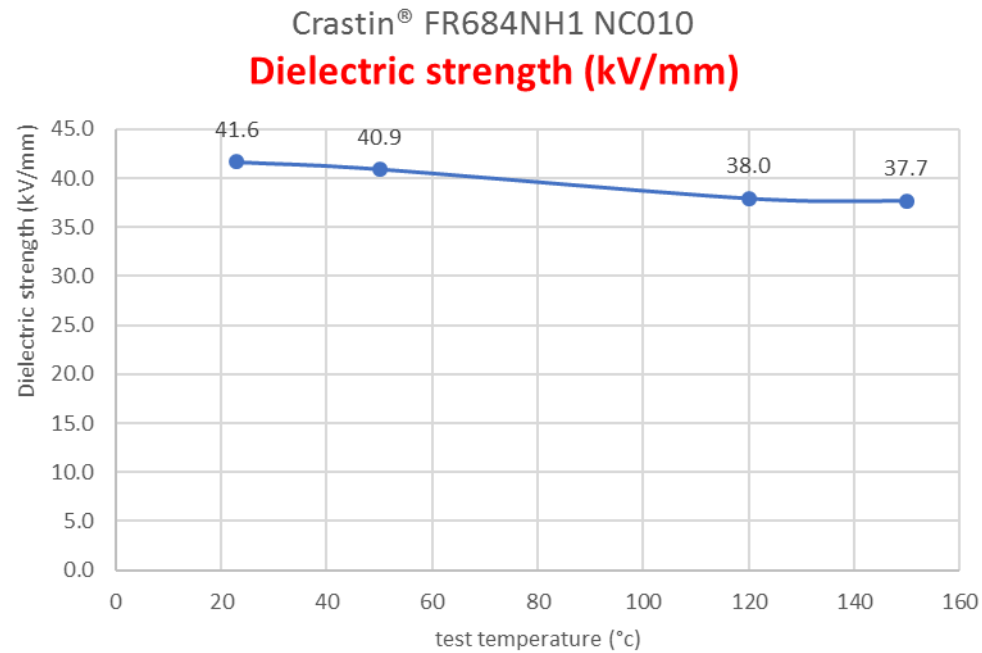


○ Polyesters provides high stable Electric Strength to environment temperature compared with polyamide group



# Electrical properties at elevated temperatures

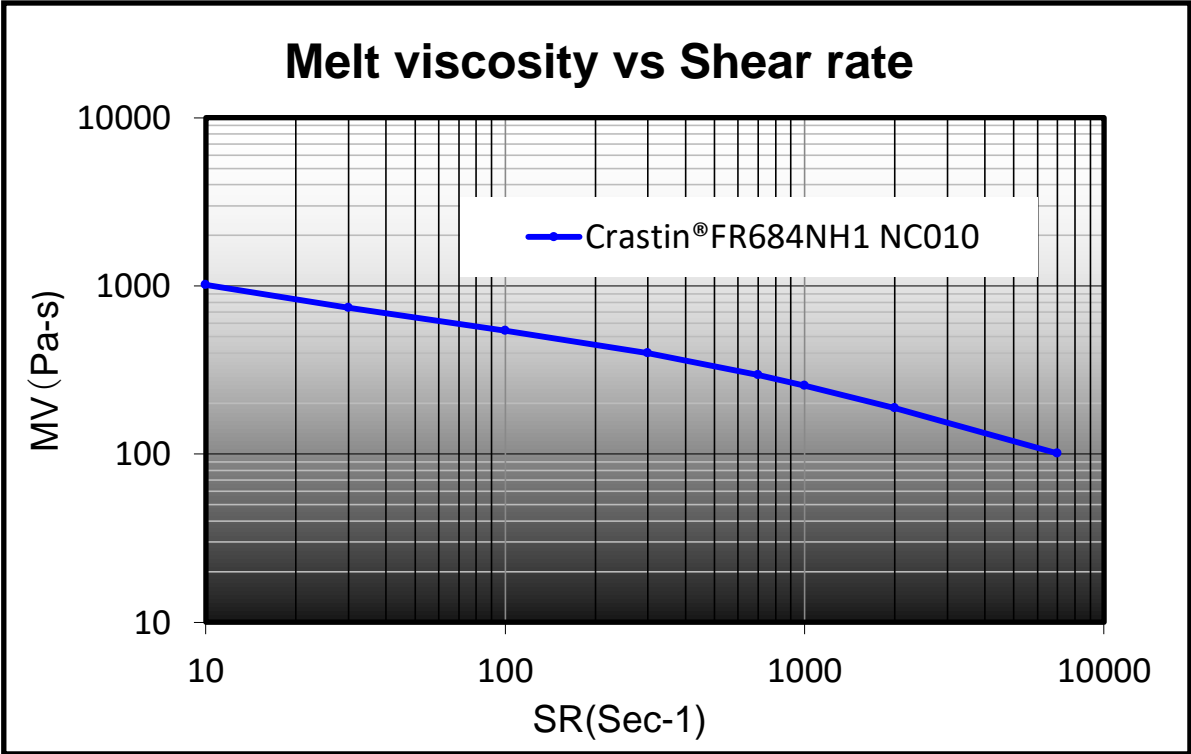
## Crastin® FR684NH1



# Melt Viscosity

## Crastin® FR684NH1

Melt viscosity vs Shear rate



### Condition

- Sample pellet
- HUT 5min.
- Temperature 250°C
- Shear Rate 10~7000Sec-1
- Drying temp 130°C Vacuum dry x 1hr

MV comparison  
(historical average in commercial production)

Melt Viscosity (Pa · s)	
Shear Rate (Sec-1)	Crastin®FR684NH1 NC010
10	1018
30	743
100	544
300	400
700	295
1000	256
2000	188
7000	101

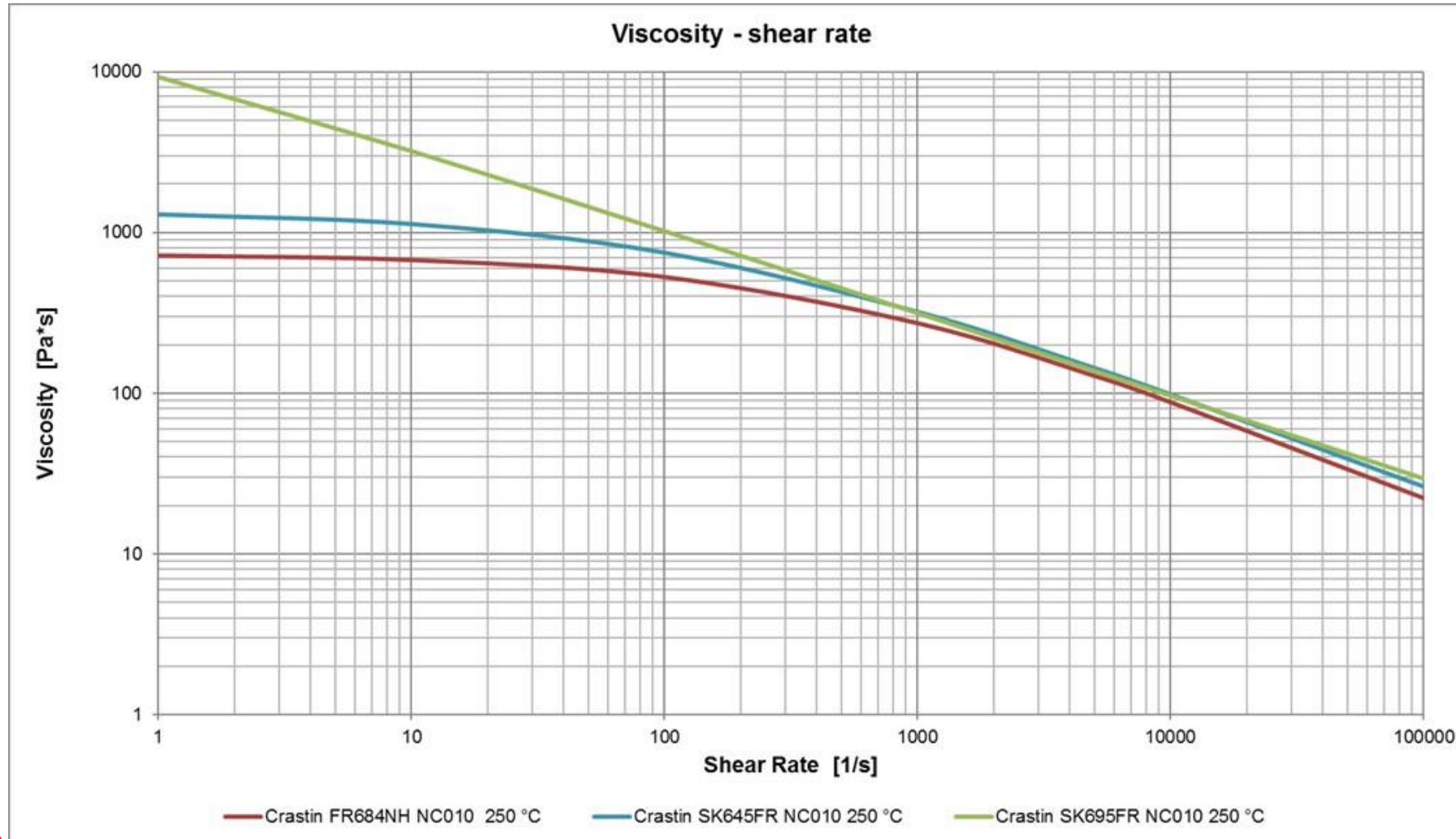
Melt Viscosity at 1000 sec-1 (Pa · s)	
Crastin® SK645 BK851	Crastin® FR684NH1 BK591
348	236

○ Smaller MV than halo FR grade



# Melt Viscosity

Crastin<sup>®</sup> 30% GR halogenated vs. 25% GR non-halogenated



# Color stability of Orange color at 140°C (dry)

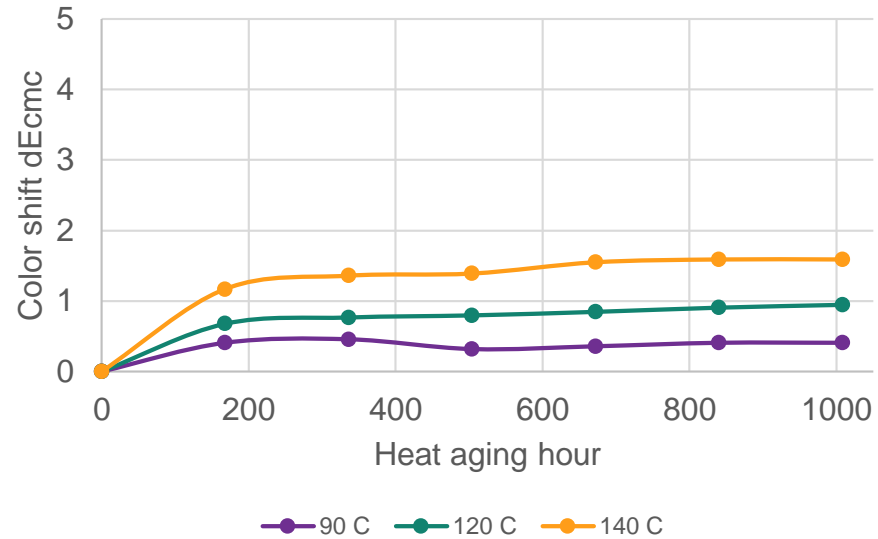
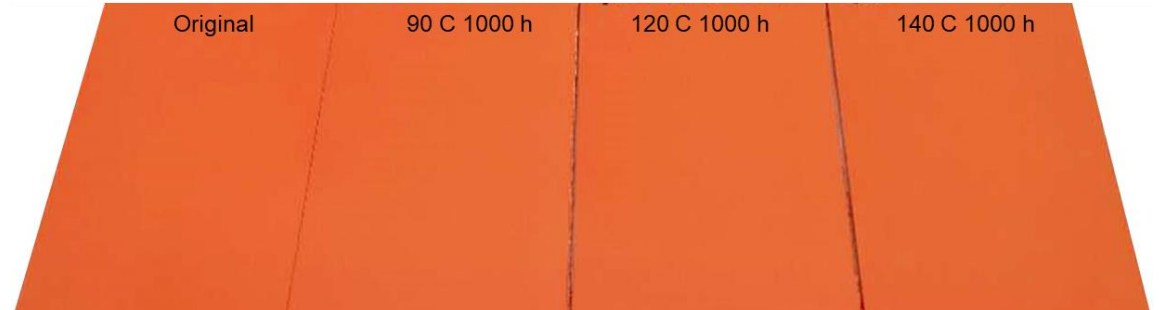
Crastin® FR684NH1 OR162



Color reading of color chip under D65 illuminant

L*	a*	b*
61.91	46.59	50.94

Heat aging performance



- No obvious color shift after heat aging under 90 / 120 / 140 C
- dEcmc = 0.4 after 90 C 1000 hour heat aging
- dEcmc = 1.0 after 120 C 1000 hour heat aging
- dEcmc = 1.6 after 140 C 1000 hour heat aging

# Processing Recommendations

## Crastin® FR684NH1 - Molding Conditions

- Drying: 110-130° C, 2-4 h by dehumidified dryer
- Processing moisture content: <0.04 %
- Melt temp: 240-260° C
- Mold temp: 80° C
- Hold-up time: 5-10min (**optimum:<3min**)
- Injection speed: 90mm/s
- Holding pressure: 60MPa

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	Cylinder Temp. (°C)			Melt Temp.	Mold Temp.
Nozzle	Front	Center	Rear	°C	°C
255	255	250	245	240-260	30-130

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\* These are general processing guidelines, but each customer needs to test parts for the specific conditions.

# Collaboration with DuPont



# How we work



Through continuous dialogue with our customers. By listening to and understanding their needs and ambitions, we're able to think innovatively to address future business needs.

Collaborative thinking means working in partnership with our customers to deliver innovative, targeted solutions. It's working together, sharing ideas and insight.

We build cutting-edge solutions and future technology. Creating ground-breaking product applications for our customers around the globe.



# Creating Value for Customers



# Recap - Crastin® FR684NH1 Product Summary

## Environment Friendly

- Non Halogenated \* FR 25% Glass Reinforced PBT
- Comply with RoHs, WEEE, REACH standards
- Free of substances as PHAs, BPA, Red Phosphorus, Bromate, Chlorine, Antimony



## Design & Cost Optimization

- Drop in material vs standard PBT with good balance of mechanical properties in terms of stiffness, toughness and elongation.
- Miniaturization - High flow; High CTI; High RTI
- Lower density (cc. -10%) vs. PBT Halogenated

## Safety & Reliability

- UL 746B RTI Electrical =130°C at 0.75 mm
- More stable dielectric strength
- Higher CTI 600V(PLC0) vs Halog. FR PBT (eg. CRASK645FR)
- Electric strength (1mm) (IEC 60243-1) : 44 kV/mm

## Flammability

- UL94-V0 @ 0.75mm – **NC, GY, BK, WT**; 0.4mm – **OR** (Orange)
- GWIF 960 °C at 0.75 mm
- GWIT 750 °C at 0.75 mm

## Others

- Colors: Natural, Orange, Gray, Black, White
- Laser Markable in Black & Orange color
- Good surface appearance
- Low mold deposit and low melt corrosion



# Resources for Support

**DuPont Material Data Center – <https://dupont.materialdatacenter.com/>**

A new digital platform enables access to new DuPont branded technical datasheets for Transportation & Industrial

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