Novel black masterbatch solutions for automotive PP compounds subjected to prolonged heat exposure

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- Cabot at a glance
- Specialty carbon blacks and their function in (automotive) plastics
- The opportunity for polypropylene in automotive applications – and the “LTHS problem” of black PP compounds
- Introducing VULCAN© XTP50 carbon black– the solution to black LTHS PP compounds
- Summary and Outlook

Cabot Corporation At-a-Glance

Global specialty chemicals and performance materials company

Key Statistics

1882
Founded

Boston, MA
Headquarters

~$6.1B
Market Cap[1]

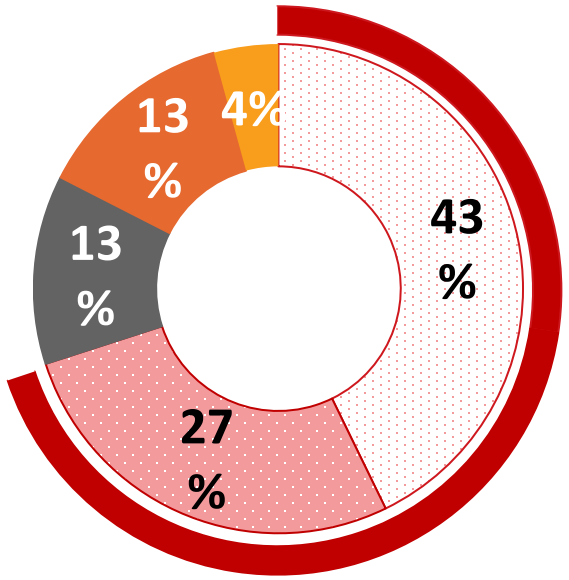
~4,300
Employees

38
Plant Locations

50+ Years
Dividend History

End Market Sectors[3]

Revenue (%)



FY24 Financial Highlights

$4.0B
Revenue

$777M
Adjusted EBITDA[2]

19%
Adj. EBITDA Margin[2]

19%
Adj. ROIC[2]

$479M
Discretionary Free Cash Flow[2]

1. As of September 30, 2024
2. Non-GAAP Measure – See Appendix
3. Percentage of FY24 Segment Revenue

Segment Overview

#1 or #2 BUSINESS POSITIONS

REINFORCEMENT MATERIALS

Global leader with durable, growing earnings, and robust cash generation

Reinforcing Carbons

Engineered Elastomer Composites (E2C®)

PERFORMANCE CHEMICALS

Portfolio of leading high-growth, high value product lines, aligned with favorable macrotrends

CARBON & SILICA TECHNOLOGIES (CST)

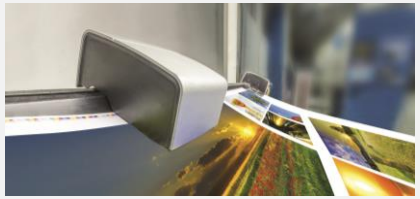
Specialty Carbons

Specialty Compounds

Fumed Metal Oxides

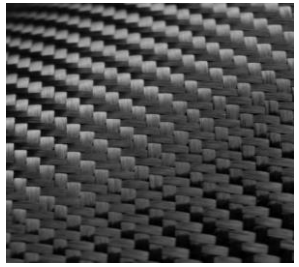
Battery Materials

Aerogel



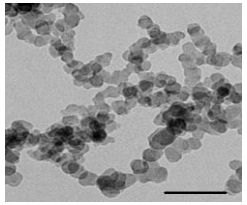
Inkjet Colorants

Specialty carbon blacks for plastics – tailored to application requirements across many markets

MOLDING	CONDUCTIVE	FIBER	PIPE	WIRE & CABLE	FILM
◆ **General molding** ◆ **Engineering plastics molding**: Automotive, electronics equipment, household appliances and industrial equipment.	◆ **ESD compounds:** Preventing electrostatic discharge (safety and equipment protection) ◆ **Conductive compounds:** Various applications	◆ **Polyamide fiber** ◆ **Polyester fiber** ◆ **Polyolefin fiber**	◆ **Pressure Pipe:** Gas pipes and potable water pipes ◆ **Other pipes**	◆ **Semicon:** Conductive layer inside the cable for homogenization of the electric field ◆ **Jacketing**: Outside layer	◆ **Packaging films:** General packaging, food packaging ◆ **Agricultural films:** Mulch films, silage films ◆ **Specialty films:** Geosynthetics
◆ Deep black color (jetness) ◆ Good dispersibility ◆ Surface smoothness ◆ UV protection	◆ Conductivity ◆ Low loadings	◆ Deep black color (jetness) ◆ Good dispersibility ◆ Excellent filterability ◆ Minimal impact on Spinnability	◆ Most cost-effective UV weathering protection (during outdoor storage) ◆ Good dispersibility ◆ High purity	◆ Semicon: Conductivity and cleanliness ◆ Jacketing: UV protection	◆ UV protection ◆ Deep black color ◆ Food contact ◆ Low moisture absorption
					

A short introduction to carbon black (CB) and its general role in (automotive) plastics

CB morphology



Distinct types of carbon black differ in terms of the following morphology characteristics:

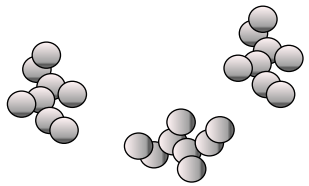
- Particle size / surface area
- Structure
- Surface chemistry

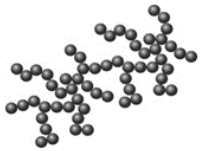
CB features

Depending on its morphology, carbon black delivers a performance profile along the following main features:

- Color strength
- UV absorption
- Dispersibility (affects mechanical properties)
- Surface reactivity / interactions

CB functionalities





Larger particle size:
- Lighter color
- Weaker UV protection
- Easier to disperse

Smaller particle size:
- Darker color
- Better UV protection
- More difficult to disperse

Lower structure:
- Stronger color
- More difficult to disperse

Higher structure:
- Weaker color
- Easier to disperse

Lower surface reactivity:
- Little interactions with resin and additives

Higher surface reactivity:
- More interactions with resin and additives

The role of automotive PP compounds – and why they often contain carbon black

Why PP in Automotive

- **Lightweight:** Helps reduce vehicle weight and improve fuel efficiency.
- **Cost-Effective:** Lower raw material and processing costs compared to engineering plastics.
- **Versatile:** Can be easily compounded with fillers and additives for tailored performance.
- **Good Balance of Properties:** Impact resistance, stiffness, chemical resistance, and surface finish.
- **Recyclability:** Supports circular economy initiatives in automotive manufacturing.

PP Automotive Applications

- **Interior:** Instrument panels, door trims, consoles, pillars, seating components.
- **Exterior:** Bumpers, grilles, fender liners, wheel arch covers.
- **Under-the-Hood:** Battery trays, air intake manifolds, fan shrouds, covers.

Why CB in PP Compounds

- **Coloration:** Deep, durable black aesthetics for visible parts.
- **UV Protection:** Shields PP from sunlight, preventing fading and degradation.
- **Thermal Stability:** Improves resistance to long-term heat exposure, slowing aging.

Powertrain electrification is beneficial for PP – but challenges remain

Internal Combustion Engine (ICE) Vehicles	Traditional under-the-hood plastics face very high peak temperatures (up to 200–250 °C)	Preferred polymer - Polyamide
Electric Vehicles (EVs)	Absence of ICE results in lower peak and operating temperatures (near battery: 120-150 °C)	Preferred polymer - Polypropylene (PP)

- EV parts must last longer (10–15 years) with minimal degradation, whereas ICE parts often get serviced or replaced more frequently.
- EV architectures are compact → less airflow and heat dissipation, leading to higher steady-state temperatures.
- OEM standards (e.g., VW44045: 150 °C for >1,000 h) are still applied to ensure robustness.

→ **Requires PP with LTHS (long-term heat stability)**

For PP parts near battery and in HVAC system

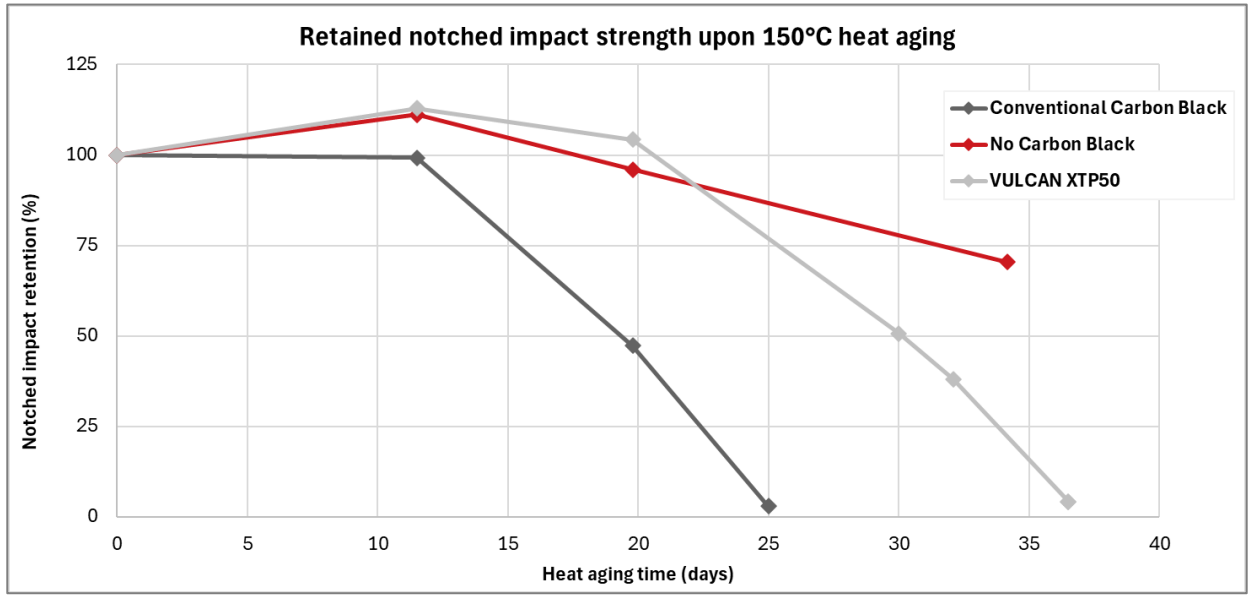
So, what is the problem? And how does it relate to carbon black?

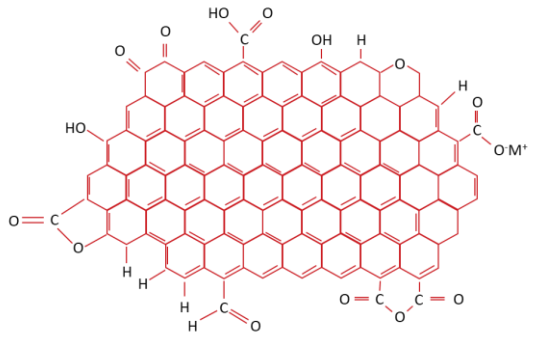
Long-**t**erm **H**eat **S**tability (LTHS) is the ability of a material to maintain its properties when exposed to elevated temperatures over extended periods.

Typical PP compound formulations for automotive LTHS application contain expensive antioxidants (to deliver the LTHS functionality) and carbon black (for color and UV stability)

As the two additives are interacting at the surface of conventional carbon blacks, reduced efficiency of antioxidants is observed (reduced efficiency in free radical scavenging).

Assumed mechanisms (suggested by literature):
- Antioxidant adsorption onto CB surface
- Phenol, quinone and carbonyl groups participate in transfer of electrons





From problem to solution – designing the most suitable carbon black for automotive LTHS PP compounds

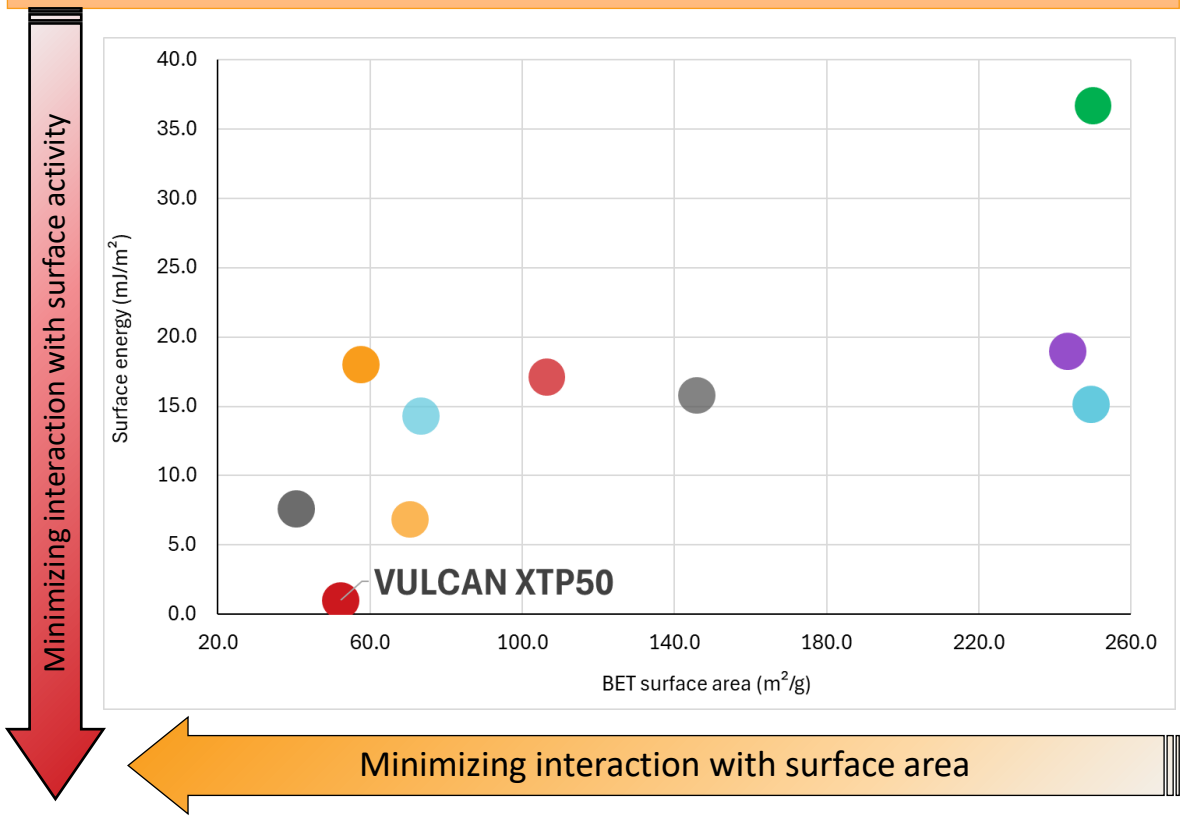
Since we observe the additive interaction at the surface of a conventional CB, limiting the possibilities of surface interactions is the goal

Reducing the total number of active groups on the CB surface is key to minimize interaction with the antioxidant

1. Selecting a lower surface area carbon black
2. Selecting a carbon black with low chemical surface activity
3. Lowering carbon black dosage

Cabot's VULCAN© XTP50 is the starting point to enable superior LTHS performance of black LTHS PP compounds.

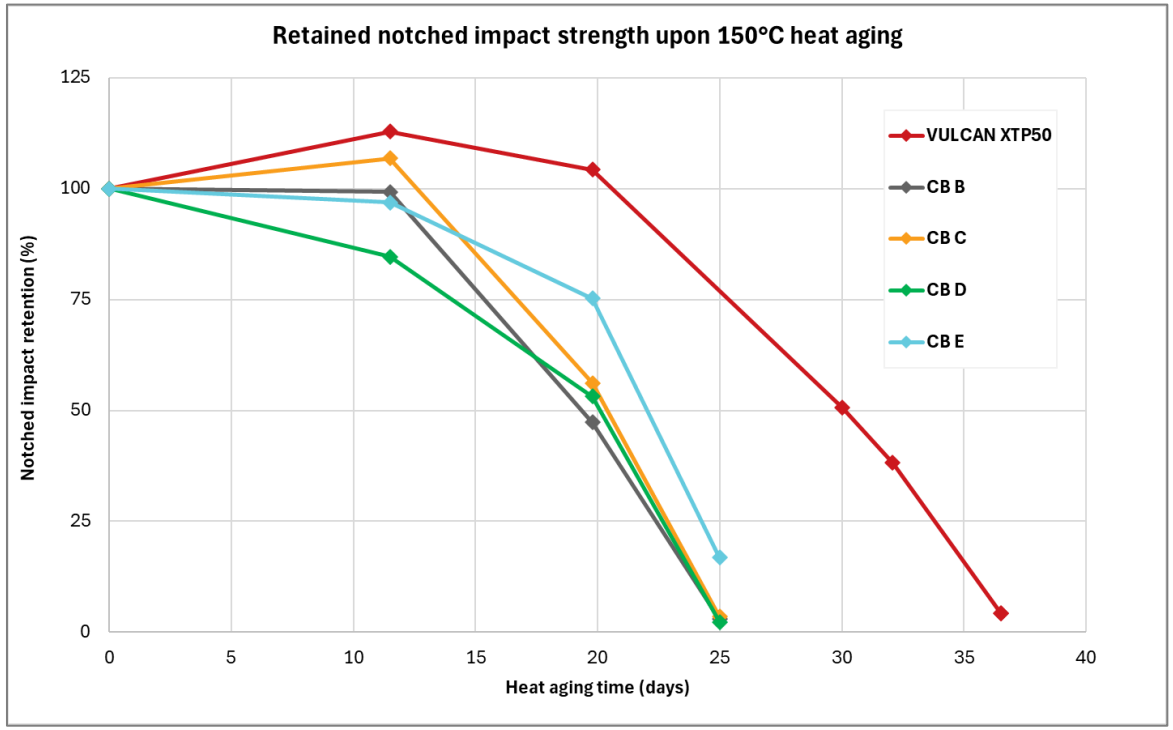
The "interaction" framework – plotting selected Cabot CB in a graph with surface area and surface activity – directly suggests VULCAN© XTP50 as the most suitable candidate



VULCAN© XTP50 CB confirms the hypothesis that low surface activity offers superior LTHS

- Model formulation: PP - 20% Talc - 0.2% Antioxidant - 1% Carbon Black
- Heat aging test at 150°C based on VW44045 to TIER1/OEM *(>27days)*
- Monitoring crack appearance time and notched impact retention

	VISUAL CRACKS APPEARANCE MONITORING DURING AGING TEST AT 150°C				
	0	300 h	600 h	900 h	>900 h
Commercial standard PP compound		Crack at the notch			
Model formulation with standard CB			Crack at the notch		
Model formulation with best-in-class CB				Crack at the notch	
Model formulation with VULCAN XTP50					

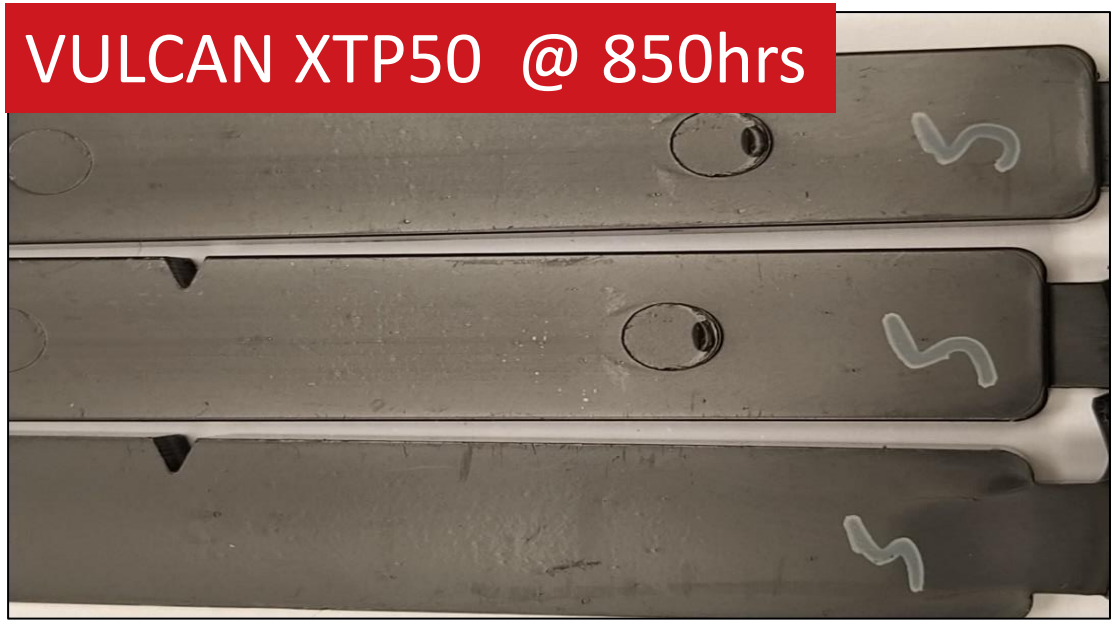


VULCAN© XTP50 CB confirms the hypothesis that low surface activity offers superior LTHS

The improvements are not just apparent in the data tables but can easily be observed on the product samples

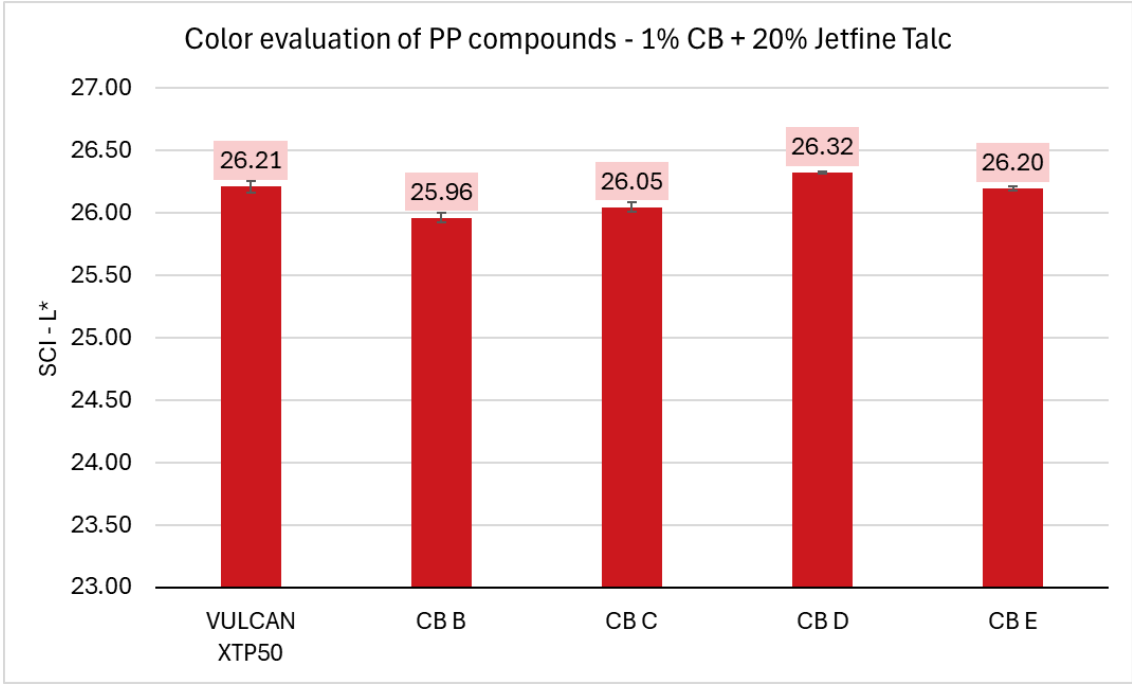
Standard UV CB @ 600hrs

VULCAN XTP50 @ 850hrs



Secondary considerations – odor and color – indicate need for additional developments

Odor rating according to VDA 270	
Best-in-class formulation with standard carbon black	**3.0**
Formulation with most standard carbon blacks	**3.5**
Formulation with VULCAN XTP50	**3.5**



- Odor – carbon black is only a minor contributor to overall odor performance – optimized formulation (masterbatch and compound) and processing (compounding, molding, conversion) are even more important
- Color/jetness – not very important for under-the-hood and HVAC – for visual applications, VULCAN© XTP50 CB is only the beginning – surface modifications can also be applied to carbon blacks with stronger color – all the way to medium color blacks (<20nm particle size)

Summary and take-away

- The automotive transition from ICE vehicles to EVs presents a **big opportunity for PP compounds**, thanks to lower peak temperatures
- Nevertheless, **long term heat stability** (LTHS) is a key performance criteria for many automotive PP applications subjected to prolonged heat exposure
- Most black automotive PP compounds use expensive antioxidant packages to compensate for negative interactions with the carbon black surface
- **VULCAN© XTP50** specialty carbon black features lowest levels of surface reactivity in Cabot's portfolio and therefore **solves the "interaction problem"**
- VULCAN XTP50 specialty carbon black is commercially available – for LTHS applications that additionally require odor and color performance, **next generation developments** are underway

THANK YOU FOR YOUR ATTENTION!

For more guidance on using Cabot's solutions in your formulations, please contact me:

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