# Using Carbon Black to Meet the Design Challenges of EV Applications

Dr J Hallett, Dr L Tunnicliffe

SHARE THE STRENGTH

FAMILIAR BONDS

COMPOUND KNOWLEDGE

MICRO MATTERS

BEYOND DURABLE

CHALLENGE TESTED

# Contents

- Introduction to Birla Carbon
- Carbon Black – Manufacturing and Key Properties
- Changing Requirements for Electric Vehicles and Potential Solutions
- Conclusions

# Birla Carbon

# Birla Carbon
## Part of Aditya Birla Group

**50**

Companies in
**36** countries across
**6** continents

**130+**

State of the art
manufacturing
facilities

**120000**

Employees making up
**42** nationalities

**USD 44.3 billion**

In revenues
Over 50% from
International operations

SHARE THE STRENGTH

# **Birla Carbon**
Global Footprint


SHARE

# Birla Carbon
## Sustainability

**PEOPLE**

We encourage a culture of responsibility that promotes the health, safety and wellbeing of our employees and the communities in which we operate.

**PRODUCT**

We are committed to producing a consistent supply of world-class carbon black for our customers, while reducing its environmental impact and ensuring that it generates real social value.

**PROCESS**

We strive to be a responsible steward of the environment by optimizing the conversion of carbon to carbon black, minimizing our carbon dioxide ($CO_2$) emissions and maximizing the recovery of the energy generated by our manufacturing process.

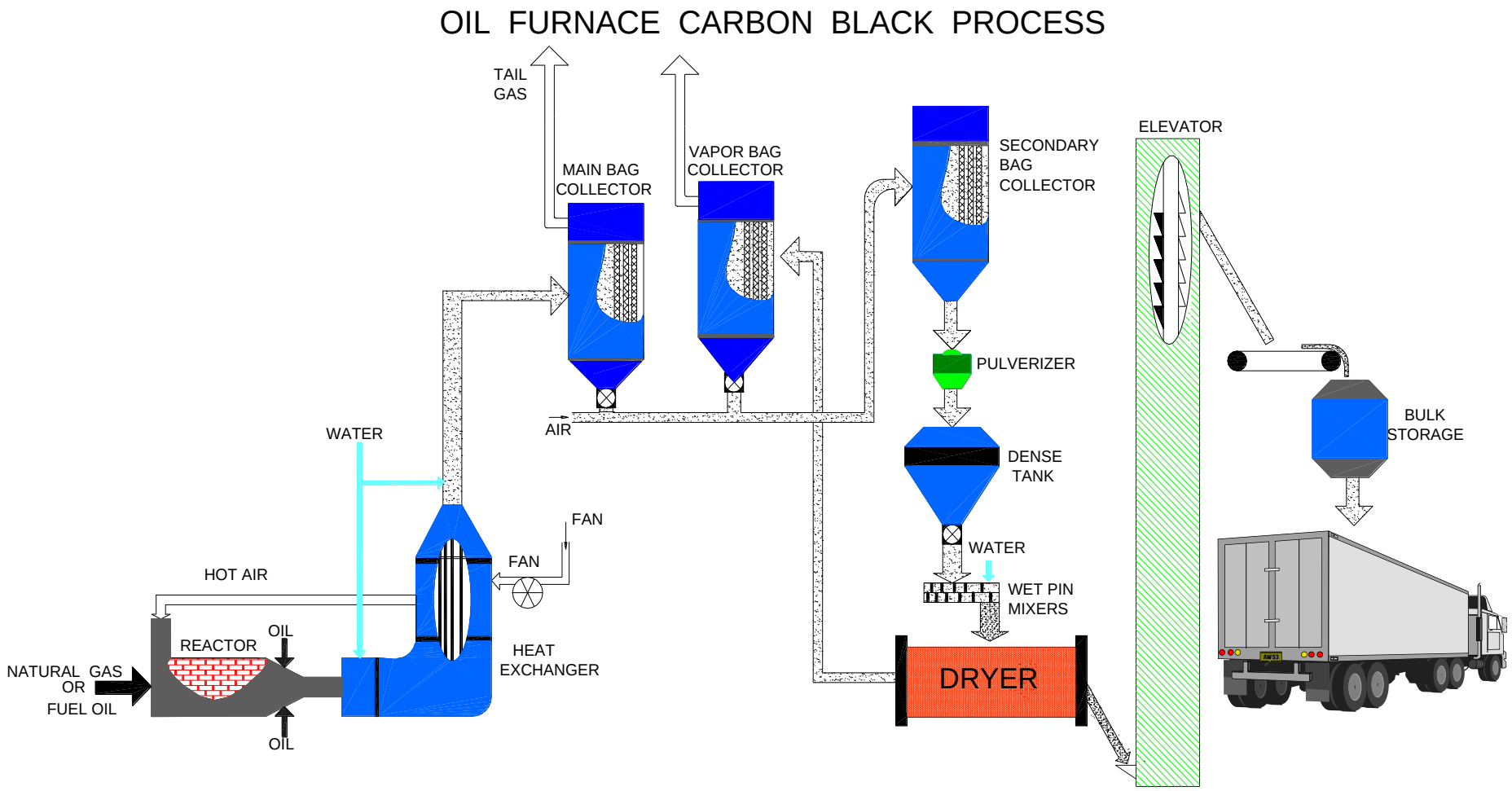
Gold rating from EcoVadis for Sustainability in 2016 to 2019

# Carbon Black Manufacture and Key Properties

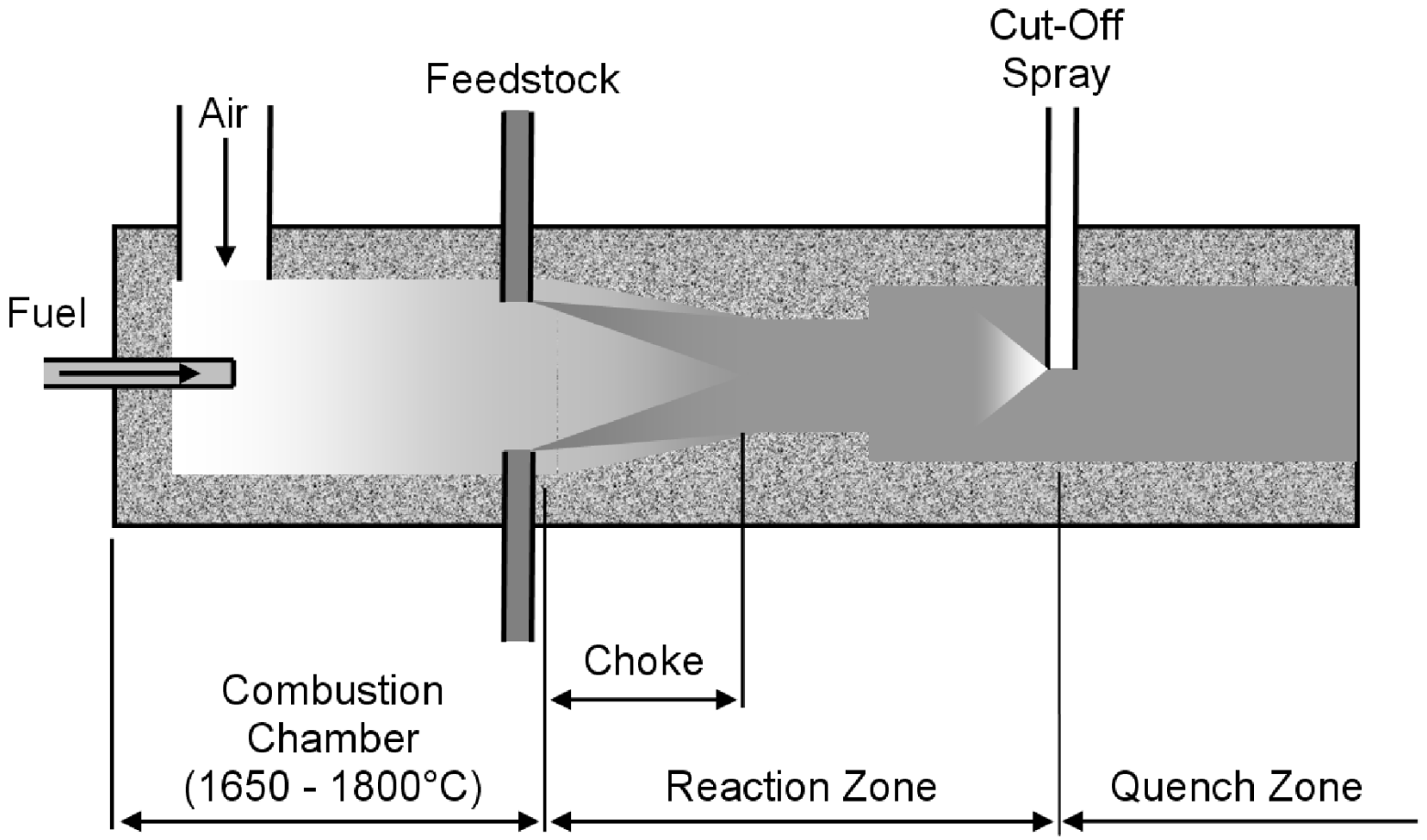
# What is Carbon Black?

- Carbon black is a virtually pure colloidal form of elemental carbon
  - A Colloid is a system in which finely divided particles, which are approximately 10 to 10,000 angstroms in size, are dispersed within a continuous medium in a manner that prevents them from being filtered easily or settled rapidly
- Carbon black is formed by the thermal decomposition (incomplete combustion) of a hydrocarbon feedstock
- Total world capacity exceeds 12 million MT per annum

# Carbon Black
## Furnace Plant Schematic

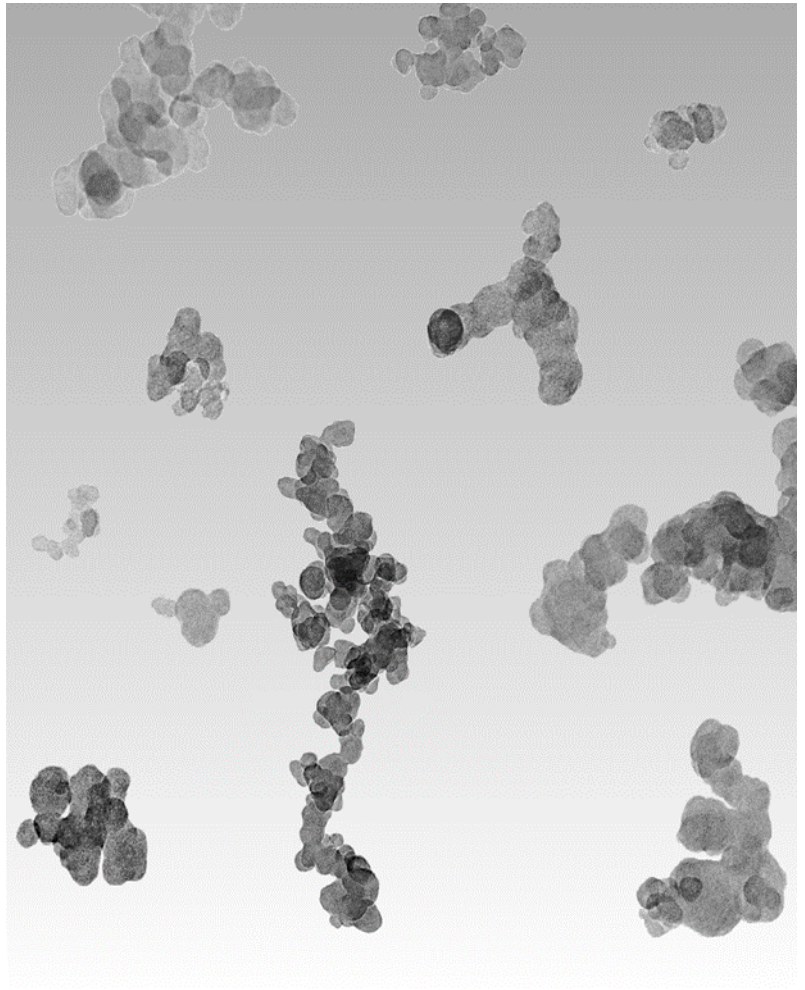


# Carbon Black
## Furnace Reactor Detail



# **Carbon Black**
## Fundamental Properties

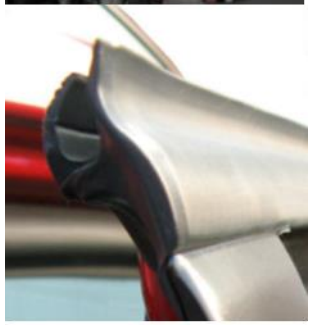
- A given sample of Carbon black can be defined by a series of fundamental properties
- Morphologically it is defined by:
  - Particle Size and its Distribution
  - Aggregate Size and its Distribution
  - Aggregate Shape
  - Pore Size Distribution
- Other properties include
  - Surface Activity
  - Impurities (carbon & non carbon)
  - Physical Form



# Elastomers in Electric Vehicles

# Where are Elastomers Used in Vehicles?

- A typical car contains over 60kg of elastomeric material
- Applications include
  - Tyres
  - Weatherstrip around doors, glass and other openings
  - Suspension
  - Body isolation
  - Motor mounts
  - Coolant Hoses
  - Drive shaft boots
  - Dual mass flywheels……
- Many of these applications are affected by the increased electrification of vehicles

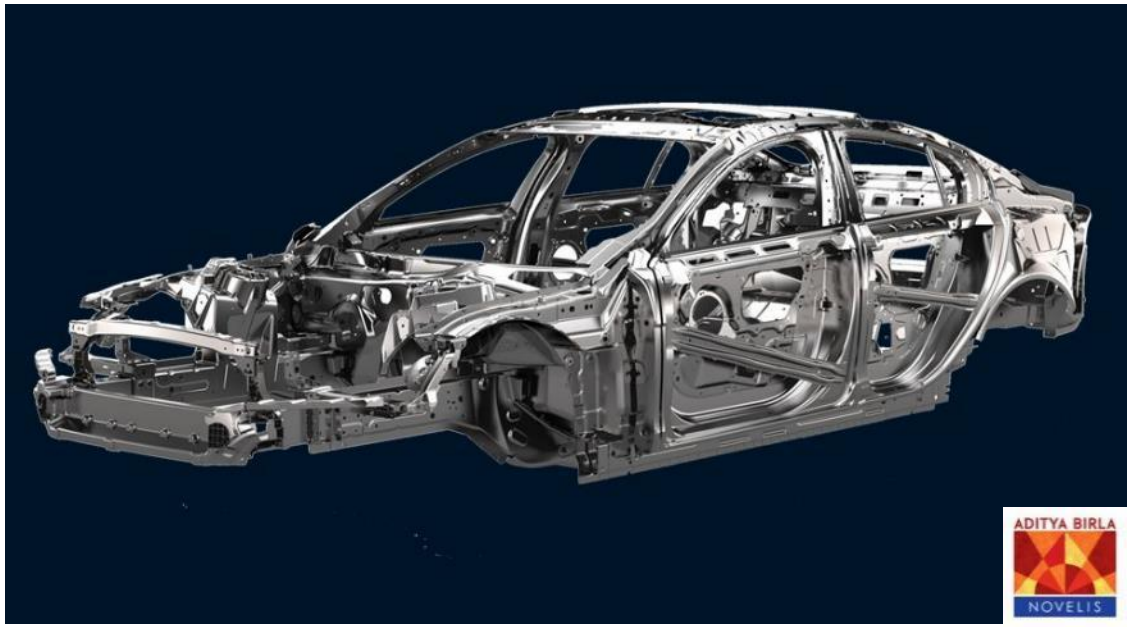


# Trends in Car Design Affecting Rubber Components

- Increased use of lightweight materials to reduce vehicle weight
- Requirement for improved vibration isolation for passenger comfort
- Reduced rolling resistance tyres to improve range

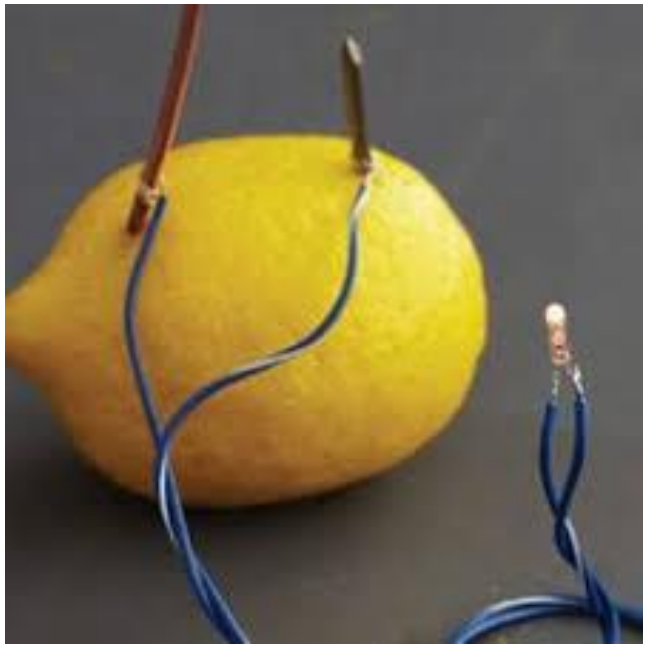
# Lightweight Materials

- For Electric Vehicles weight is possibly more important than for IC equivalents
  - Either reduce battery size and cost for given range or increase range for a given battery
- Reducing weight by 100kg reduces energy consumption 3.6% on average
- Weight reduction targets have led to increased use of lightweight materials in vehicle components
  - Aluminium and Magnesium in vehicle body components
  - Weight reduction targets for elastomeric components



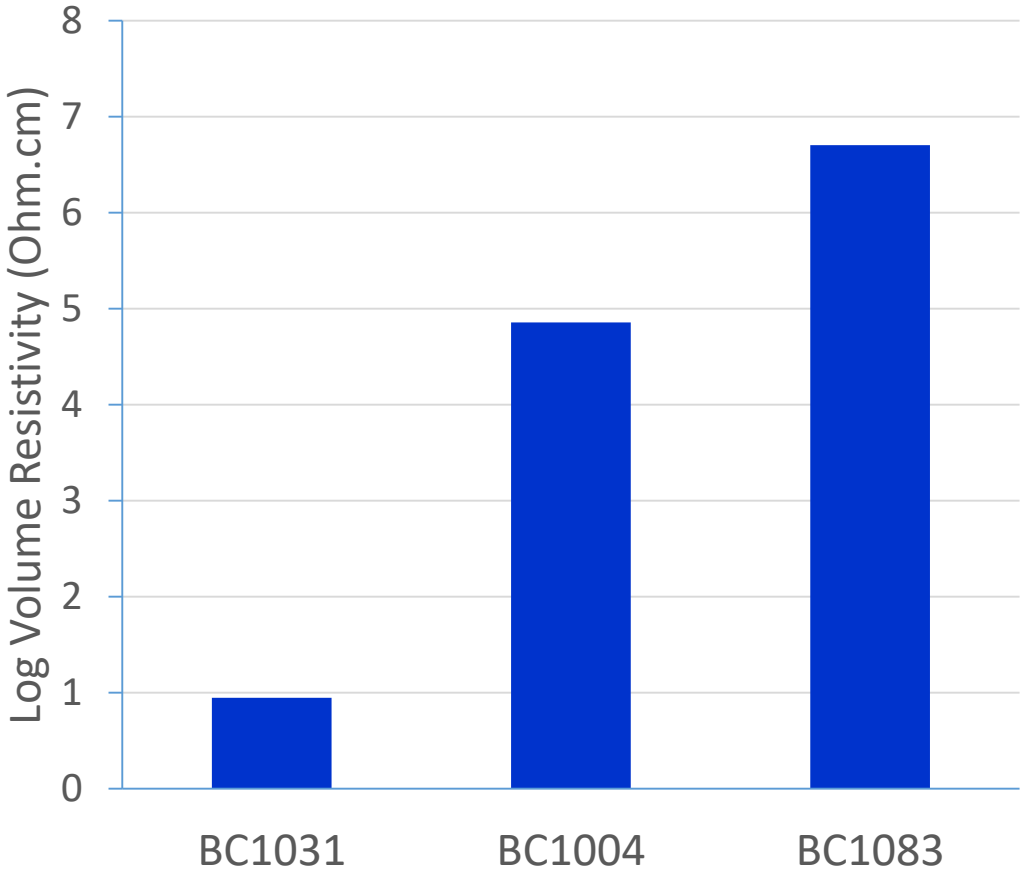
# **Challenges with Light Weight Materials:**
Galvanic Corrosion

- A carbon black filled rubber has a Galvanic Potential like all conductive materials
- In the presence of a material with a different potential and an electrolyte a galvanic cell can be created
  - For lightweight metals such as Aluminium and Magnesium this can lead to corrosion of the metallic component
- Can be prevented using a low conductivity compound



# Lightweight Material Solution:
## Low Conductivity Carbon Blacks –BC1004 and BC1083

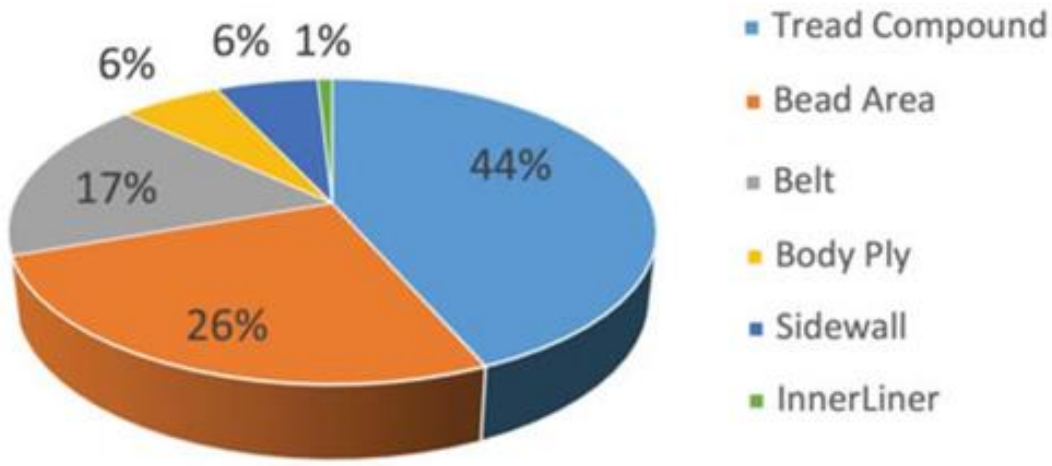
- Reducing conductivity could be achieved by adding white filler
  - Increases component weight
  - Affects final properties of compound
- Modern low conductivity carbon blacks such as BC1083 offer significantly lower conductivity than traditional N550 type products without the use of white fillers
- Minimises component weight while maintaining physical and aesthetic properties and reducing risk of galvanic corrosion




Data for EPDM with 140phr Carbon Black

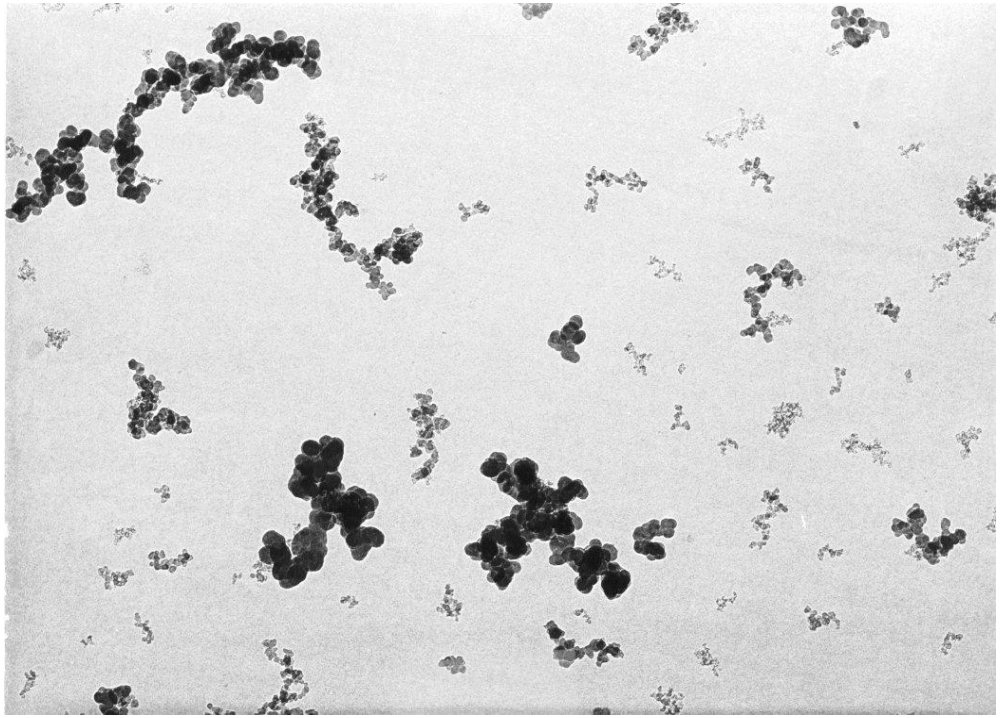
# Low Rolling Resistance Tyres

- 10% reduction in Rolling Resistance reduces energy usage by 1.5 to 3% depending on vehicle weight, tyre size etc.
  - More importance with increasing battery size (weight)
- Tread largest contribution to rolling resistance followed by the bead area
- Silica reduces RR of tread compound, but other solutions required for the carcass

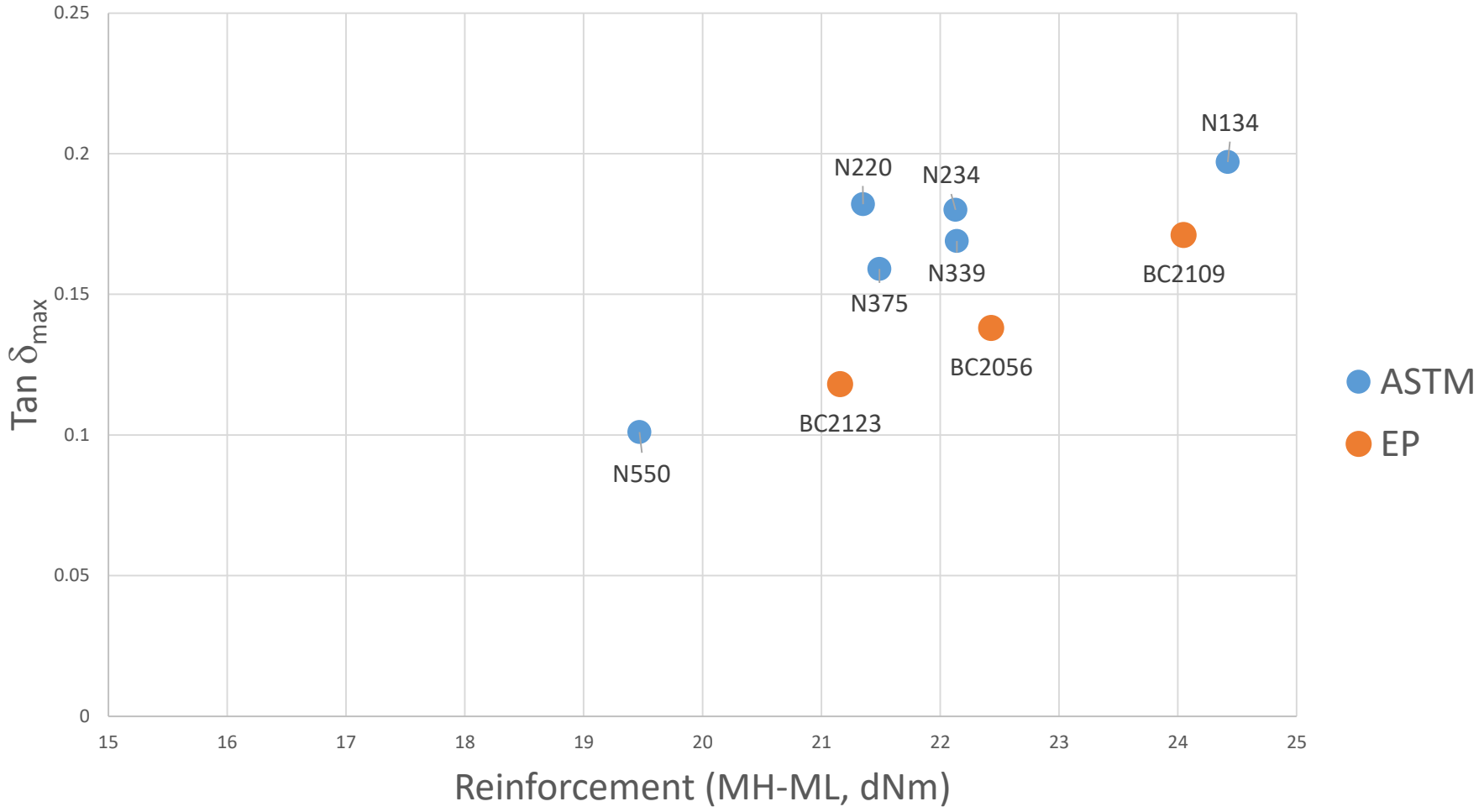


# **Solutions for Low Rolling Resistance Tyres:** Enhanced Performance Carbon Blacks

- Morphology tailored specifically to meet modern tire requirements
- Allows reduction in hysteresis while maintaining traditional carbon black benefits of
  - Good abrasion resistance
  - Good traction
  - Easier processing than silica

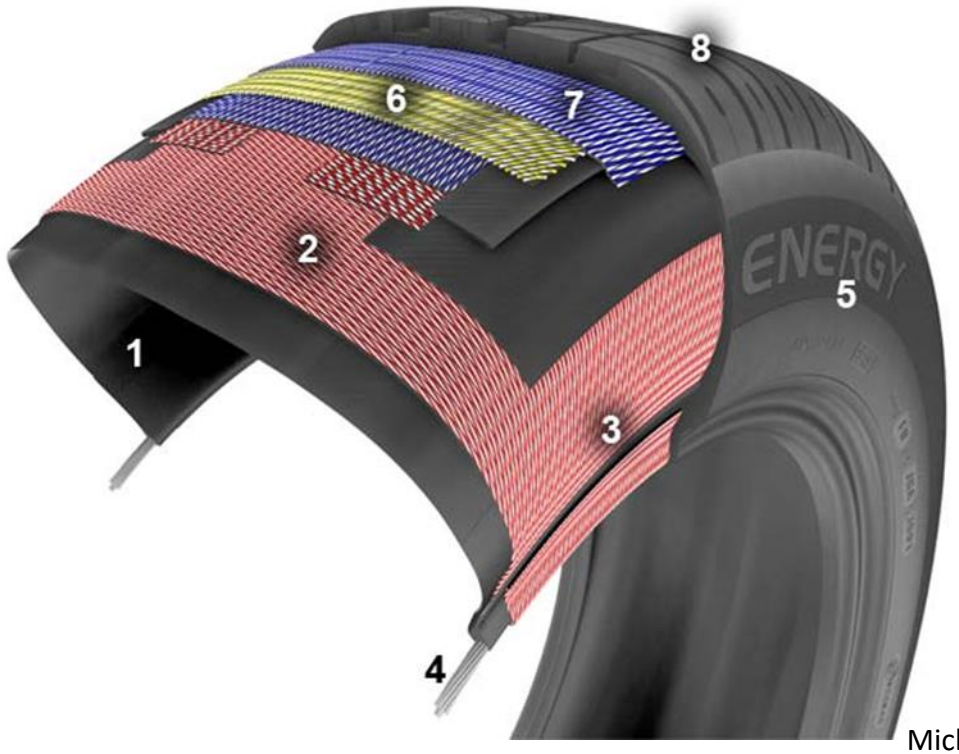


# Enhanced Performance Carbon Blacks
## In-Rubber Properties – Reinforcement vs. Hysteresis



# **Solutions for Low Rolling Resistance Tyres:** Enhanced Performance Carbon Blacks

- BC2056 in subtread
  - Reduced hysteresis while maintaining other properties
- BC2123 or BC2056 in apex (3)
  - Reduced hysteresis while maintaining stiffness
- BC2123 in skimcoat (2,6,7)
  - Lower hysteresis alternative to N326
- BC2123 in sidewall (5)
  - Create stiffer sidewall while maintaining hysteresis of traditional N550 solutions
  - Ideal for run-flat applications



Michelin

# **Solutions for Low Rolling Resistance Tyres:**
## Low Surface Area Carbon Blacks for Inner-Liners

- Traditional innerliner compounds use N660
  - Good balance between permeability, compound cost and processability
- Switching to BC1004 reduces hysteresis while maintaining permeability and other characteristics
- Low residue levels within BC1004 also allow for less scrap due to holes in innerliner materials caused by grit.

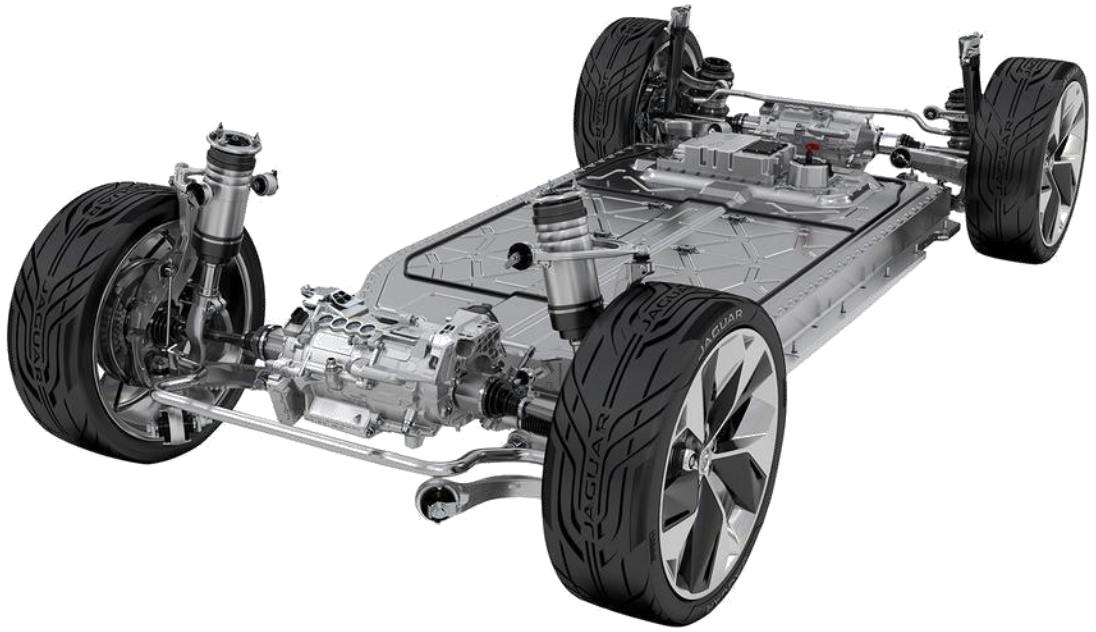
| Ingredient | N660 (60phr) | BC1004 (60phr) |
|---|---|---|
| Hardness | 54 | 53 |
| tanδ max | 0.268 | 0.251 |
| Oxygen Permeance | 23.88 | 23.59 |

# NVH
## Suspension and Body Isolation

- IC engines generate more lower frequency vibration than electric motors
  - Help mask some road noise frequencies
  - Isolation required from idle to full rpm

- EV's require isolation at lower frequencies at higher weight in suspension components
  - Requires stiffer mounts with lower natural frequency

- Hybrid vehicles worst of both worlds
  - Heavier with very wide frequency range due to combination of IC and electric power.



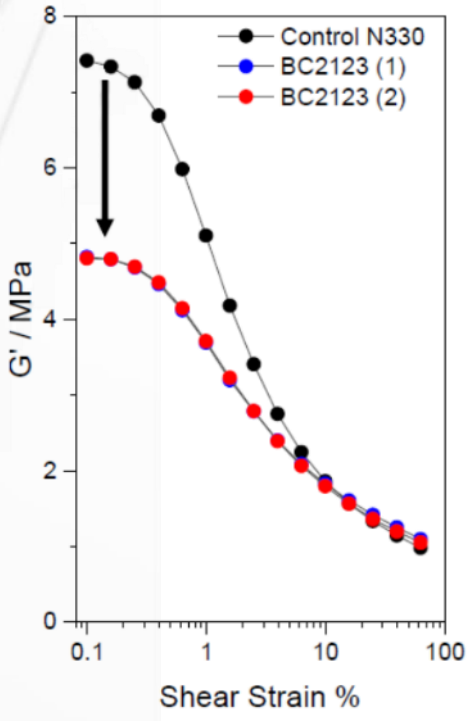
Jaguar

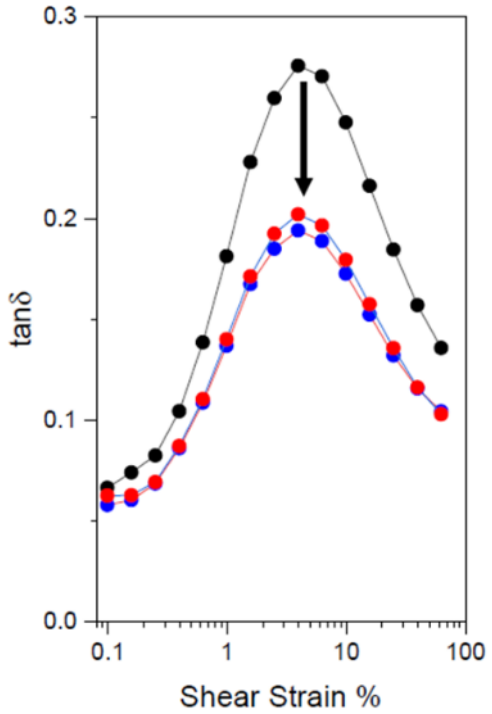
# **Solutions for Anti-Vibration:** Requirements

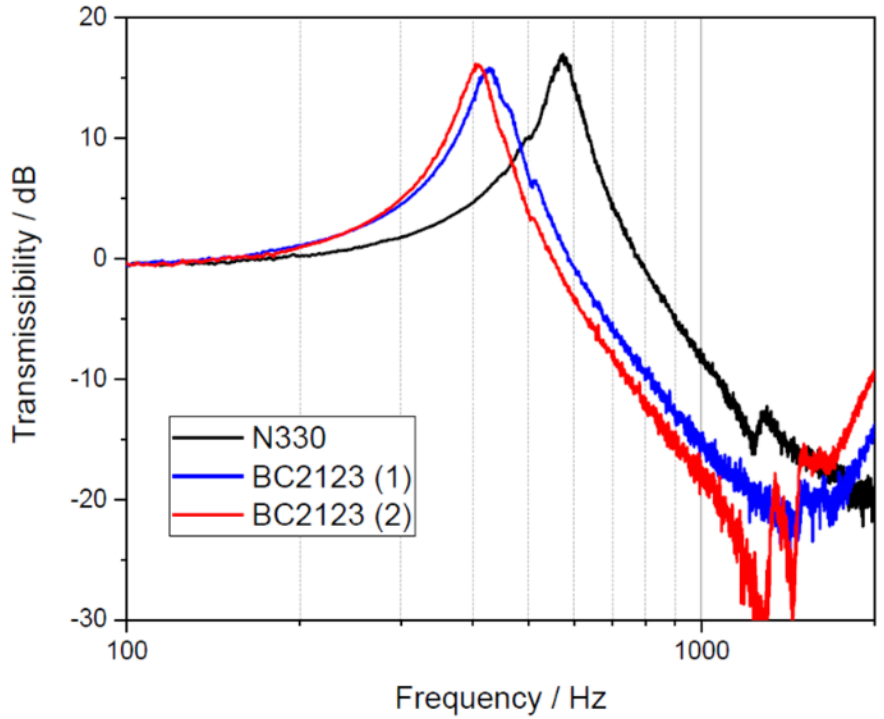
- Higher static stiffness to carry increased vehicle weight
- Lower natural frequency to allow isolation over wider frequency range
- Low spring rate ($K_d/K_s$) for reasonable isolation performance
- Good fatigue life

# **Solutions for Anti-vibration:**
# Enhanced Performance Carbon Black Grades

- Allows equivalent static properties (load carrying capability) to traditional ASTM tread grades with the following benefits:
  - Reduction in spring rate for improved isolation at equivalent static stiffness
  - Reduced natural frequency



# Summary and Conclusions

# Summary

- Electrification of fleet offers challenges to majority of rubber parts in vehicle
  - Range anxiety and battery cost leading to use of new lightweight materials and lower rolling resistance tyres
  - Change in operating conditions for vibration damping materials
- New formulations and product designs needed to meet these requirements
- Birla Carbon offers solutions to many of these new and updated requirements

# Birla Carbon Solutions

- Lightweight Materials
  - BC1083 and BC1004 to minimise risk of galvanic corrosion through lower conductivity compounds
- Lower Rolling Resistance Tyres
  - EP Tread grades for lower hysteresis body compounds
  - BC1004 for innerliners with reduced hysteresis
- Suspension Components
  - EP Tread grades for lower natural frequency and dynamic static ratio while maintaining static stiffness

# Thank You

SHARE THE STRENGTH