CABOT

Industrialization of Fine Particle Based "Products by Process" to Enable Demanding Customer Applications

Yakov Kutsovsky

Overview

- Cabot Intro – company and technology
- “Product by Process”
- New materials development for conductive and reinforcement applications
- Developing new advanced carbons – materials, process, applications, safety
- Challenges

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About Cabot Corporation

Global specialty chemicals and formulated solutions provider

- 140 years in operation
  - —Founded in 1882
- Global specialty chemicals and performance materials company
  - —45 manufacturing sites in 21 countries
- Core technical competencies in fine particles, dispersions, composites and their applications
- FY2021 sales: $3.4 B

About Cabot Corporation

- Over 130 years in operation
  - Founded 1882
  - NYSE: CBT since 1968
- Global specialty chemicals and performance materials company
- 44 manufacturing sites in 21 countries
- Core technical competencies in fine particles and surface modification
- FY2017 sales of $2.7B


carbon black **#1**


inkjet colorants **#1**


cesium formate **#1**


activated carbon **#2**


fumed metal oxides **#2**


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What drives innovation at Cabot?

Application know-how and capabilities enable insights for value creation

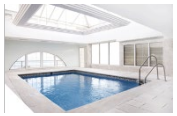
Understanding customer needs and wants

Connecting needs to Cabot solutions to create value

Market trends

Solving Customers problems!

✓ *Transportation*



✓ *Infrastructure*

✓ *Environment*

✓ *Consumer*

Megatrends

✓ *Sustainability*

✓ *Functionality*

✓ *Efficiency*

✓ *Disruption*

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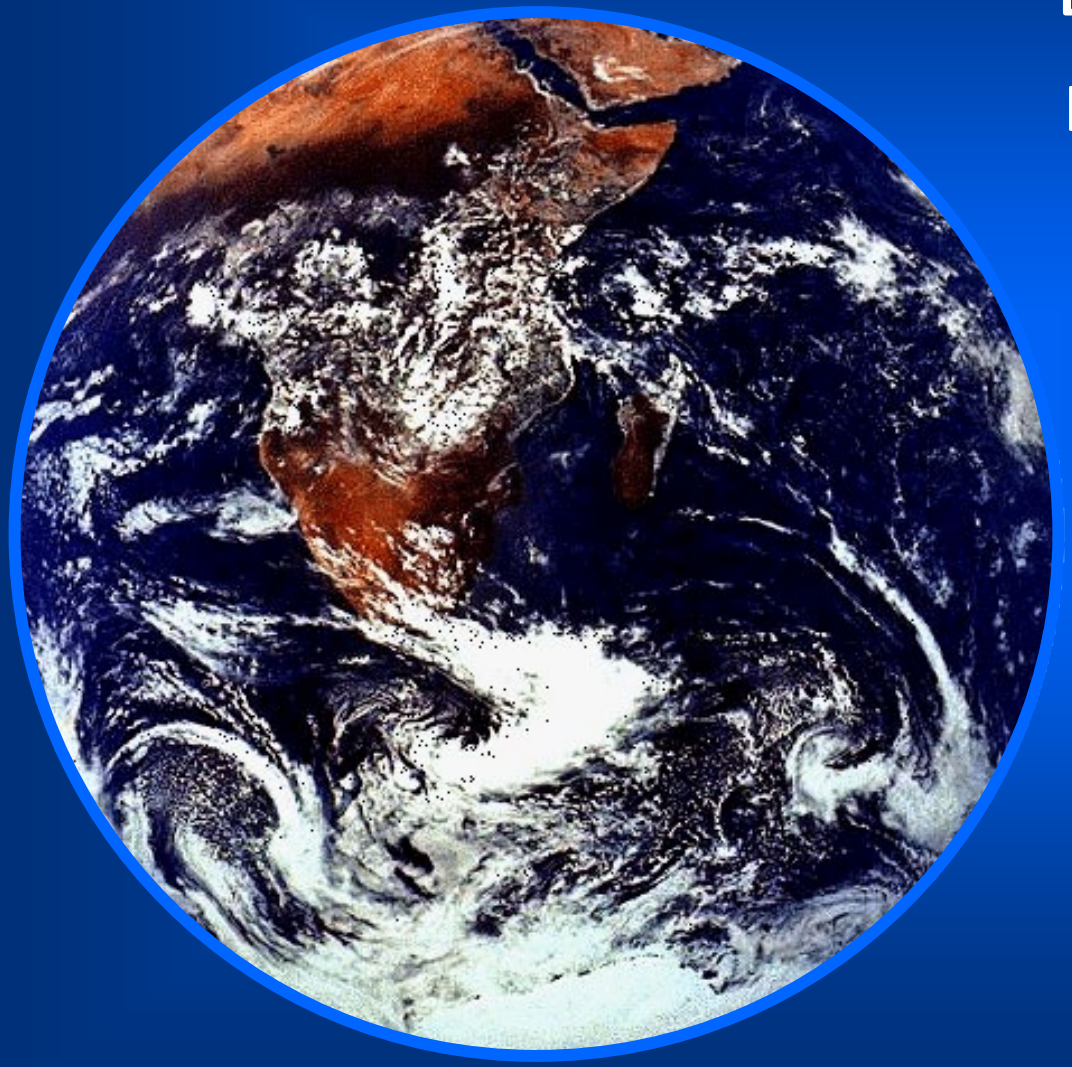


Each year Cabot makes over 250 trillion m^2 of surface area

Application-centric focus demand materials that meet applications requirements

- Beginning with application to identify unmet needs through voice of customer
- Controlling performance using both the particle and its interaction with formulation ingredients and processes
- Optimizing particles to meet application and formulation requirements

Application ⟷ **Property** ⟷ **Attribute** ⟷ **Particle**

Optical

Rheological

Mechanical

Electrical

Flow

Surface reactivity

Thermal

Particle Size

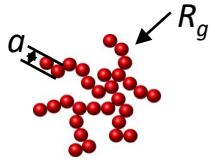
Aggregate Size

Fractal Dimension

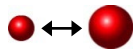
Surface Chemistry

Aspect Ratio

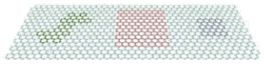
Fractal Particles



Colloidal Particles



Graphenes



Carbon Nanostructures

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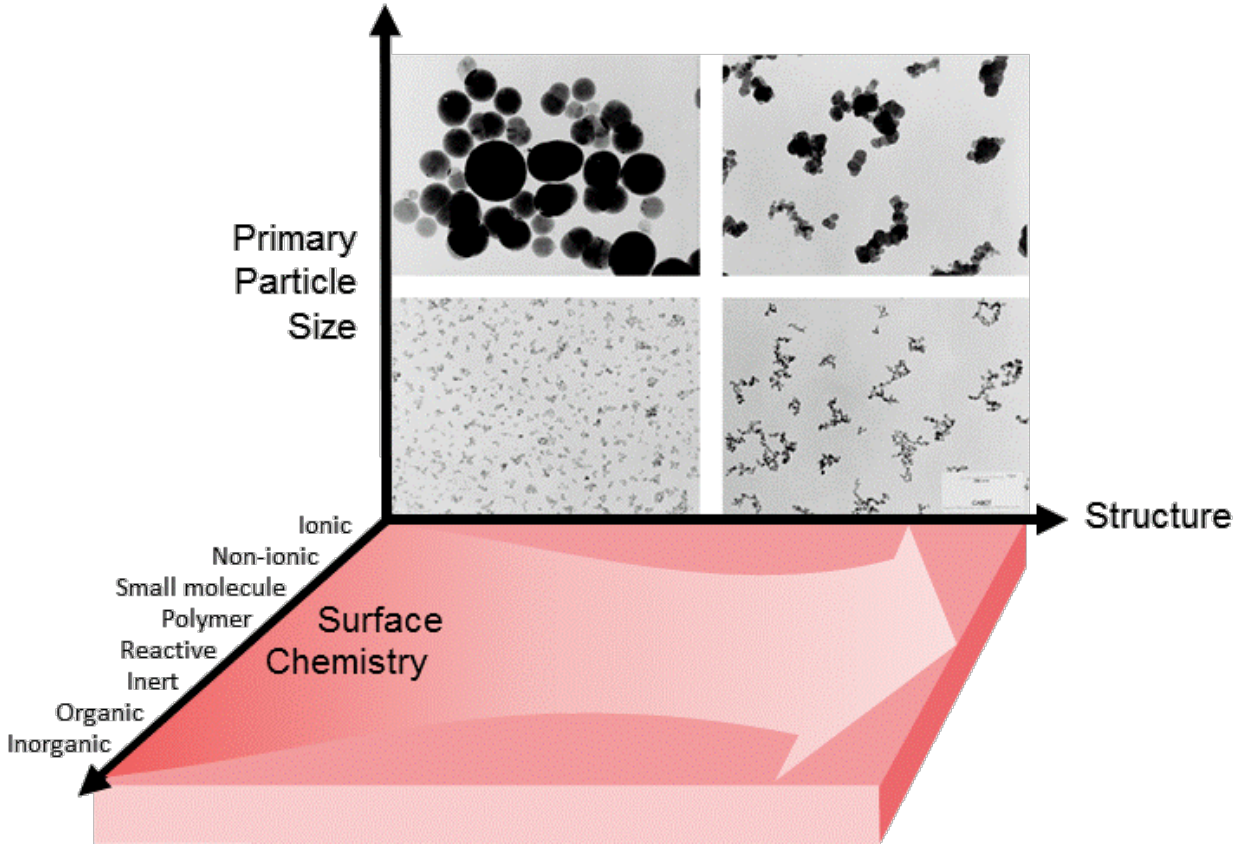
“PRODUCT” - aerosol with controlled morphology and surface chemistry to deliver functions in applications enabled by …



- Mechanical Reinforcement
- Electrical /Thermal conductivity
- Viscosity Control
- Surface Energy/ Charge Control
- Color Development
- Ease of Dispersion
- Catalyst Support
- Deliver Chemistry

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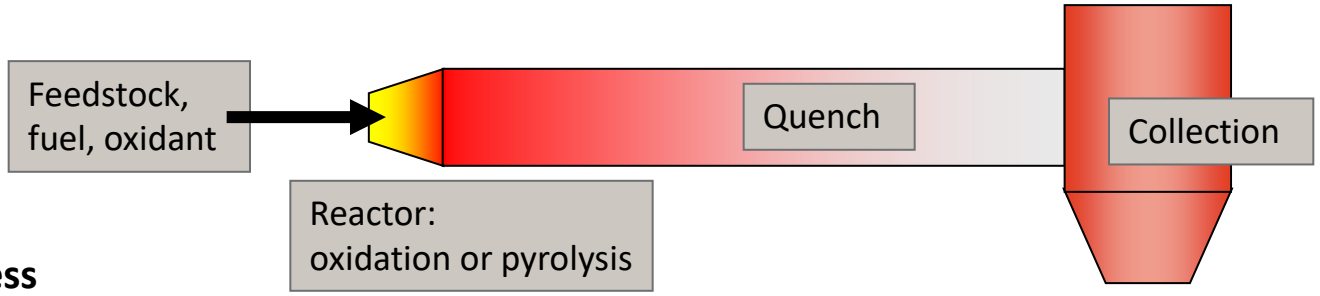
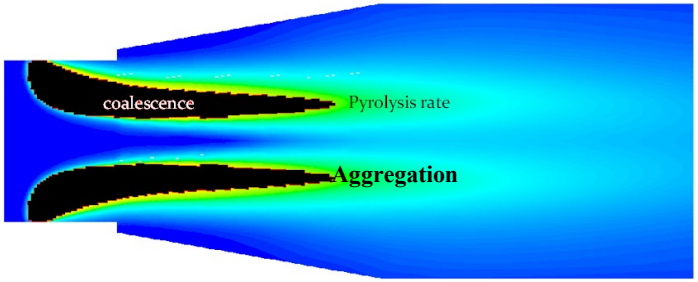
…"PROCESS" - versatile aerosol particle production technology that defines "product"

Flame Aerosol Platform



Advantages:

- **Low cost process**
- **Very high volumes possible**
- **Compositional flexibility**
- **Particle size control**



Carbon Black CFD Model

World largest carbon black plant
Tianjin, China

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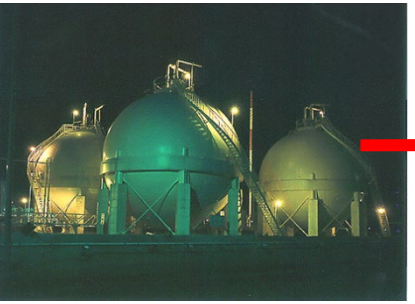
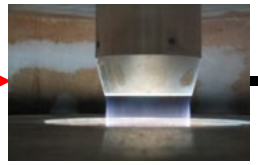
Control fumed silica production process to make key polishing slurry ingredient – “product by process”



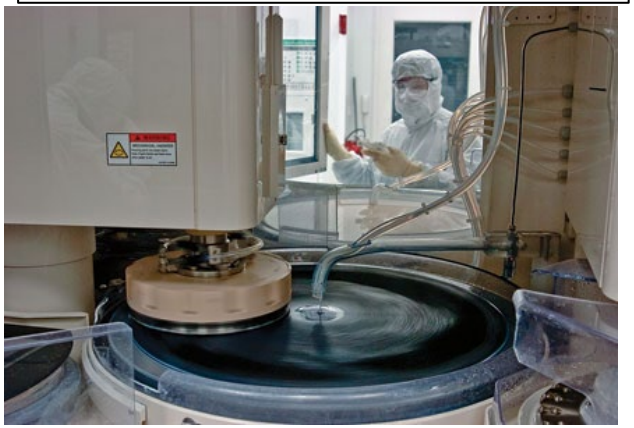
Vapor Feed System

Burner and Furnace



Gas/Silica Separation

Chemical Mechanical Polishing



In process control of over 200 parameters

Fumed Silica product control of over 20 parameters

Control large non-fumed silica defect producing particles and impurities to ppm level

C&EN 2010 VOL. 88, 28 PP. 16 - 18

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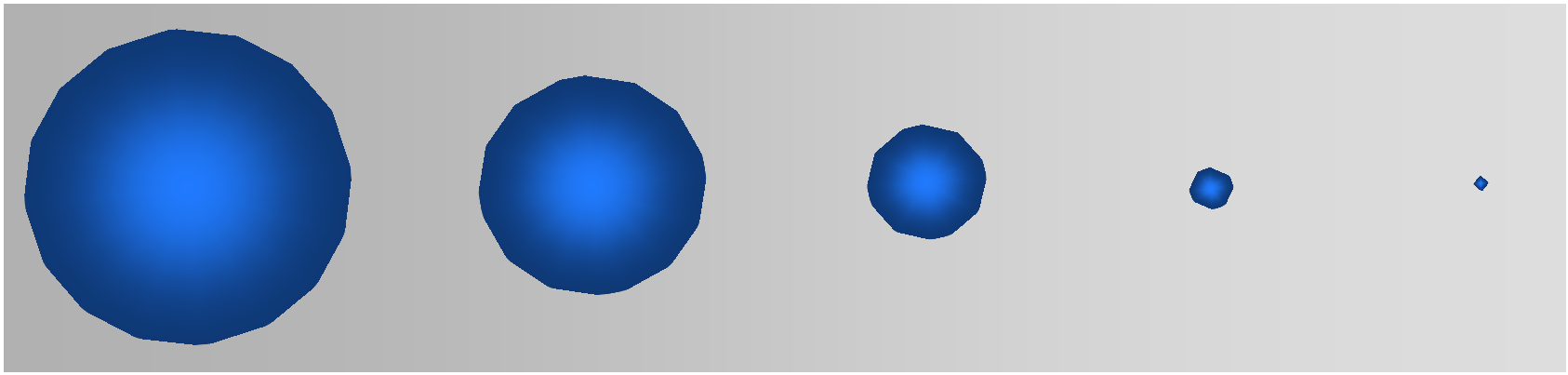
“Product by Process platforms” - scaled to serve customer applications

Carbon Black	Fumed Metal Oxides	Inkjet Colorants	Aerogel	rGO and CNS



1 million tons	10,000 tons	1,000 tons	100 tons	10 tons

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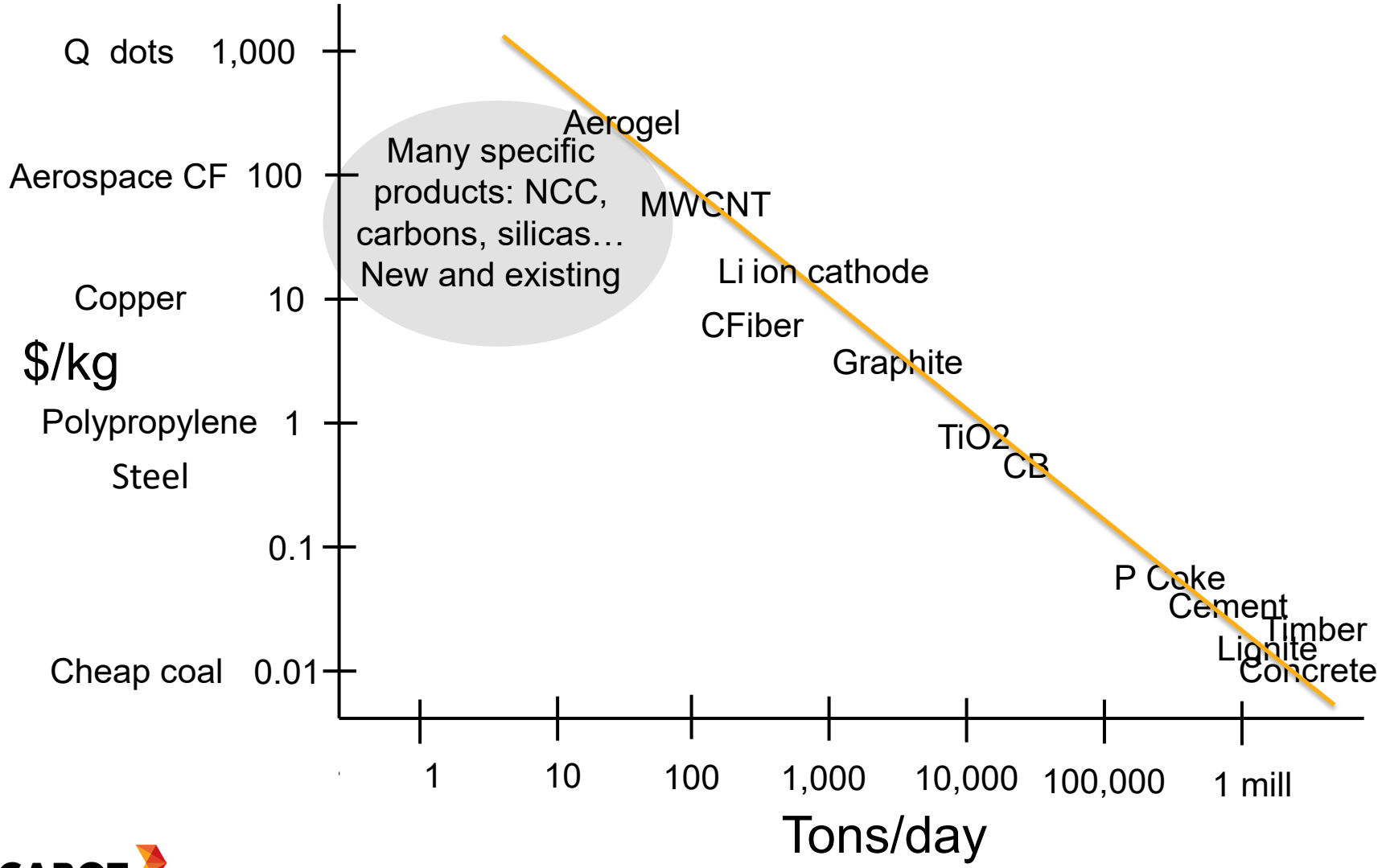
Cost and scale span many orders of magnitude– experience curve based on application cost in use



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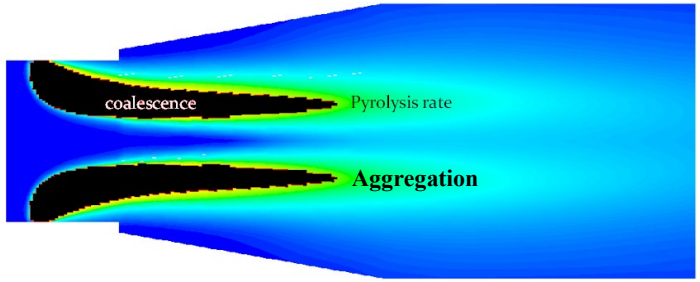
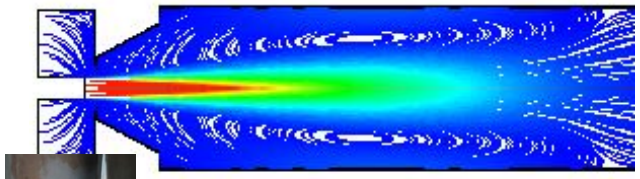
Modeling plays a key role in new processes and particles development – became important tool

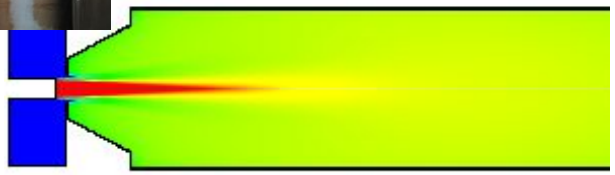
Carbon Black CFD Model



Fumed Silica CFD Model



Streamlines



Temperature

- **CFD modeling** used to predict raw materials injection, mixing, distribution, combustion, heat transfer
  - Pilot experiments have full physics, limited visibility
  - CFD simulations have limited physics, full visibility
- **Reaction kinetics coupled to aerosol models** that are calibrated by multiple controlled pilot experiments are used to predict particle production and properties
- Models predictions are **validated in experiments** and used to improve model parameters
- Provide **insights into physical processes**
  - explanation of observed trends
  - Stimulation of creative ideas
  - designing new reactors/components

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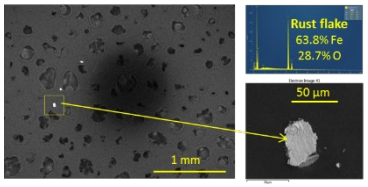
Carbon applications are enabled by combination of CB aerosol technology with chemistry, form and purity controls

Clean Technologies

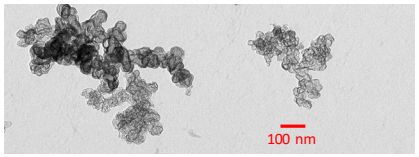
- Water
- Classification
- Milling
- Feedstock selection



Control amount and composition of impurities

Extending Morphology

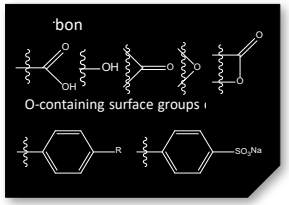
- Super-high surface area
- Super-low structure
- Super-high structure



Microporous (~1500 m²/g) CB

Surface Chemistry

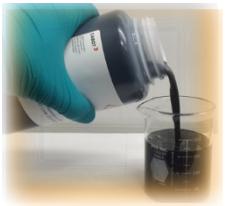
- Surface oxidation (non-specific)
- Diazonium chemistry Heat treatment (inert surface)



Typical CB functionalization

Formulated Products

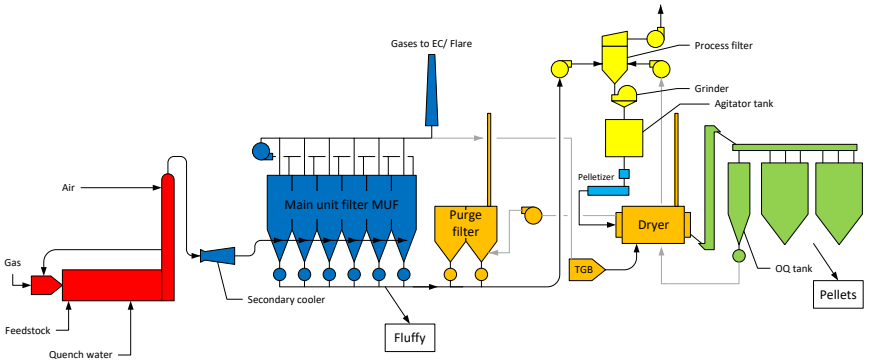
- Plastic compounds Inkjet dispersions
- Solvent borne dispersions



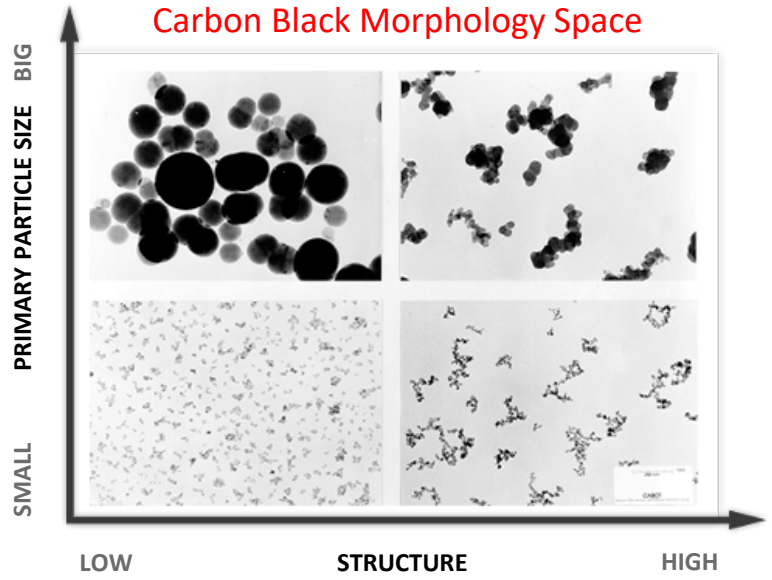
NMP dispersion for LIB cathodes

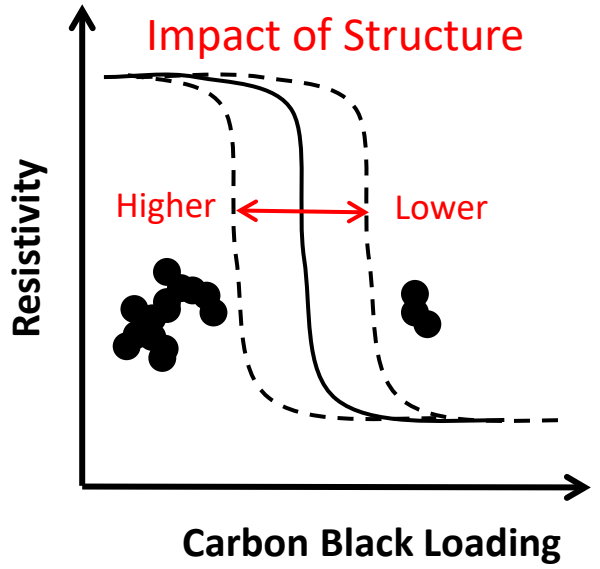
Core Carbon Black Technology

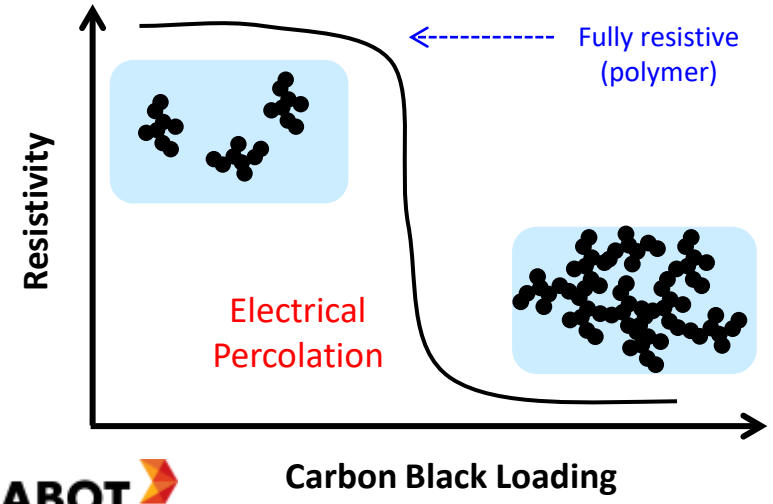
- Many Specialty Carbons are inside the same morphology space as rubber blacks

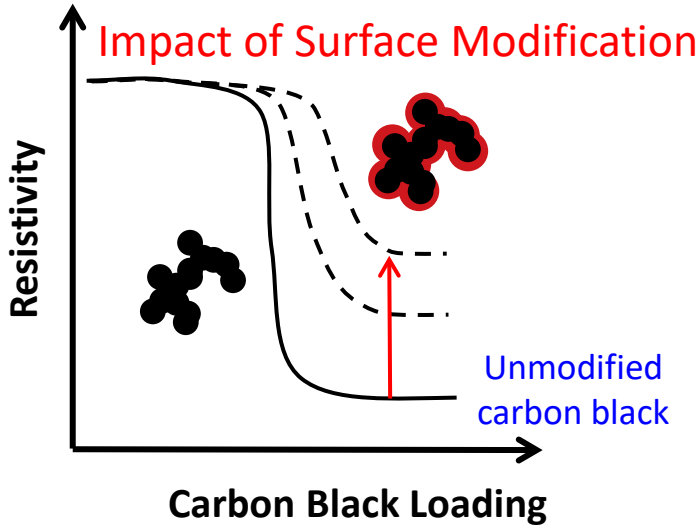


Compound conductivity can be tuned by carbon black morphology, surface chemistry, and internal structure









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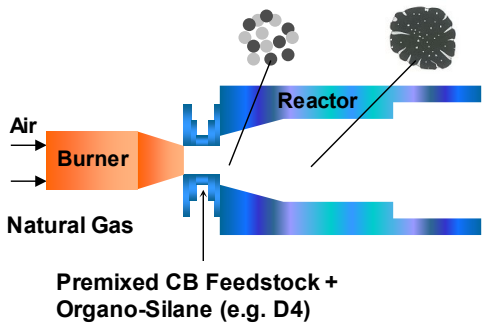
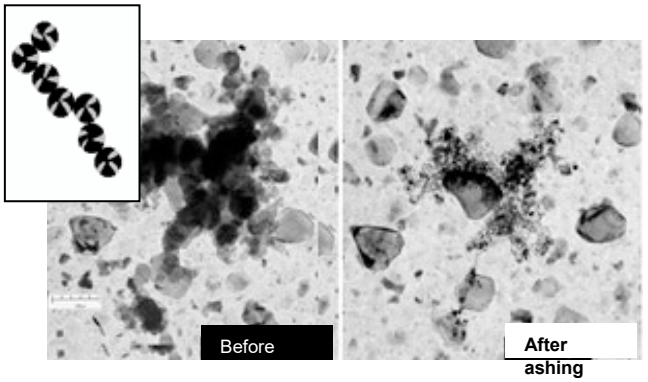
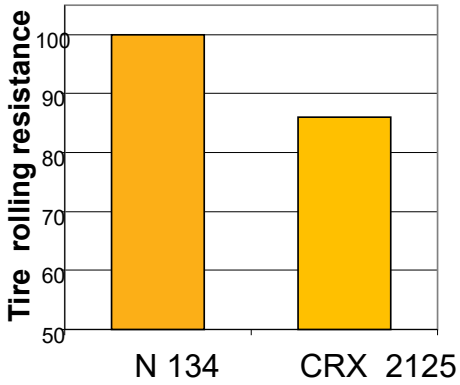
Carbon – silica hybrid particles enable control of mechanical, electrical, rheological property of compounds

Silica uniformly distributed in carbon

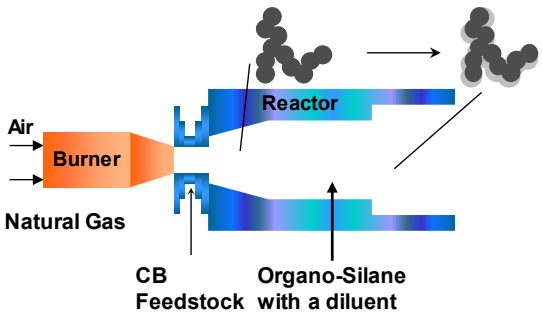


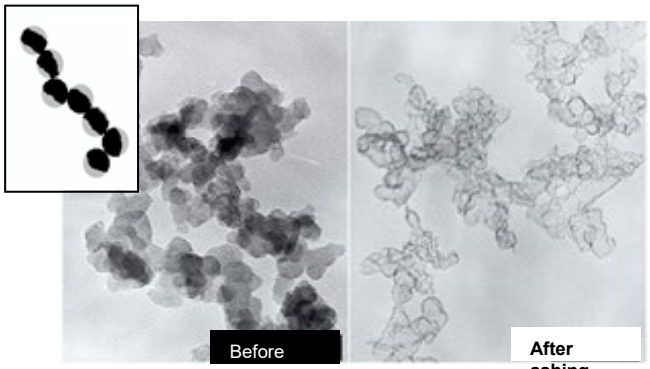


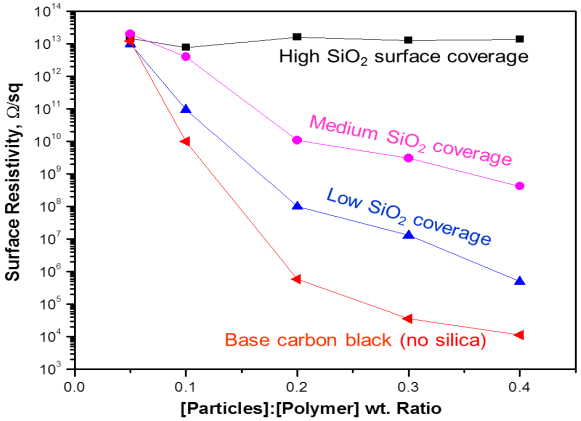


ECOBLACK™2000 – simultaneous nucleation of silica and carbon

Silica forms surface shell over carbon







ECOBLACK™4000 – coating of CB particles with silica

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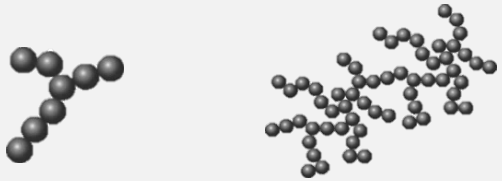
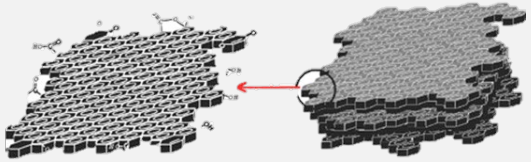
New carbon technology creates differentiated conductive network enabling high performance Li Ion batteries

Carbon Network + Carbon Conductivity

Particle Characteristics
(Size, Structure, Distribution)



Surface Properties
(Reactivity, Stability)



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Competition

Proprietary technology enables broad range of materials with varying particle characteristics to meet multiple application requirements

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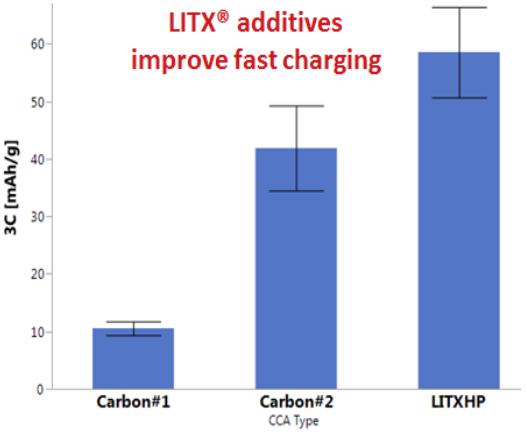
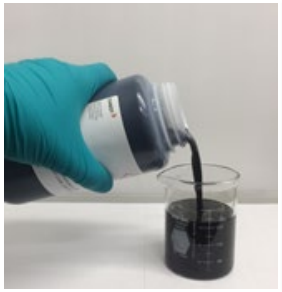
Competition

Process allows for discrete control of surface properties to enhance processing and conductivity performance

Drives Improved Li-ion Battery Performance



+ Dispersion Technology



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New materials development and commercialization require comprehensive approach

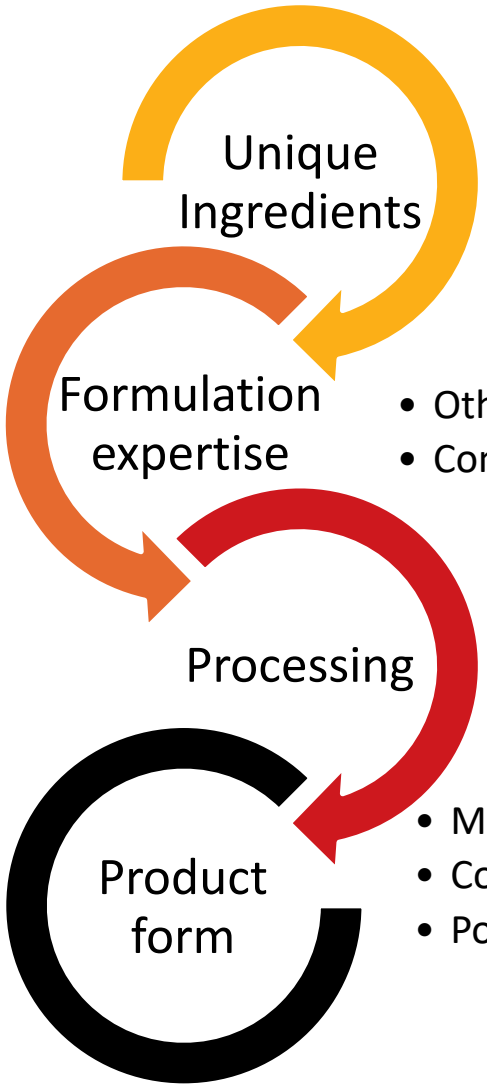
Safety, Health, Environmental

Scalable Production

Application Performance Testing

Formulation and Form
(Safe & Practical for applications)

Performance in composites is delivered using entire portfolio of advanced carbon materials

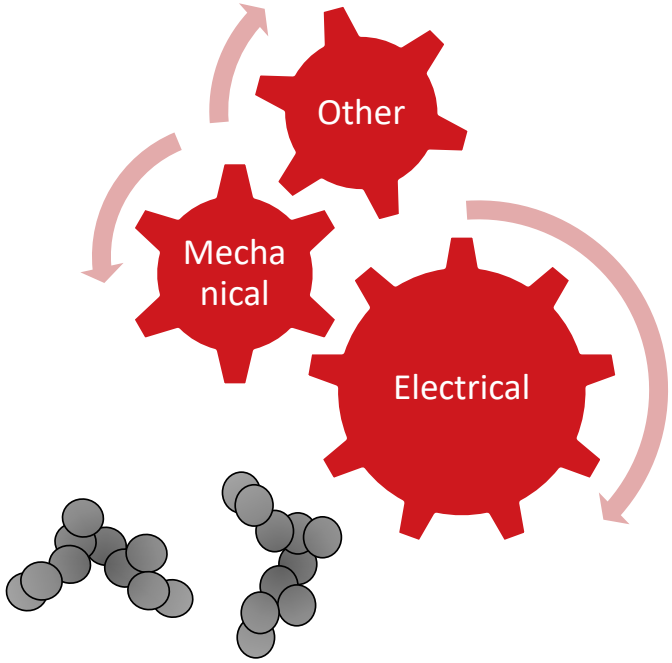


- Carbon black
- Graphenes
- Carbon nanostructures

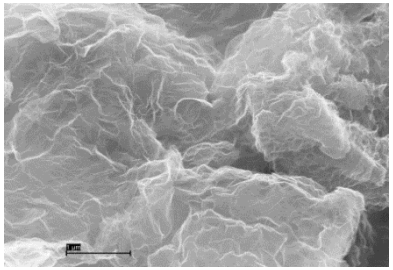
- Other ingredients
- Combination of additives

- Conventional
- Proprietary

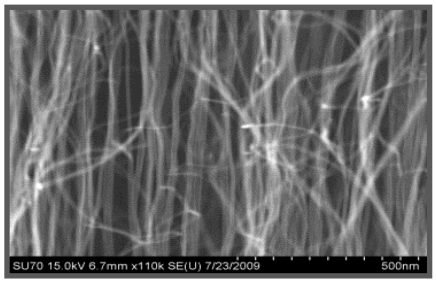
- Masterbatch
- Compound
- Powder



Carbon Black



Graphenes



Carbon Nanostructures

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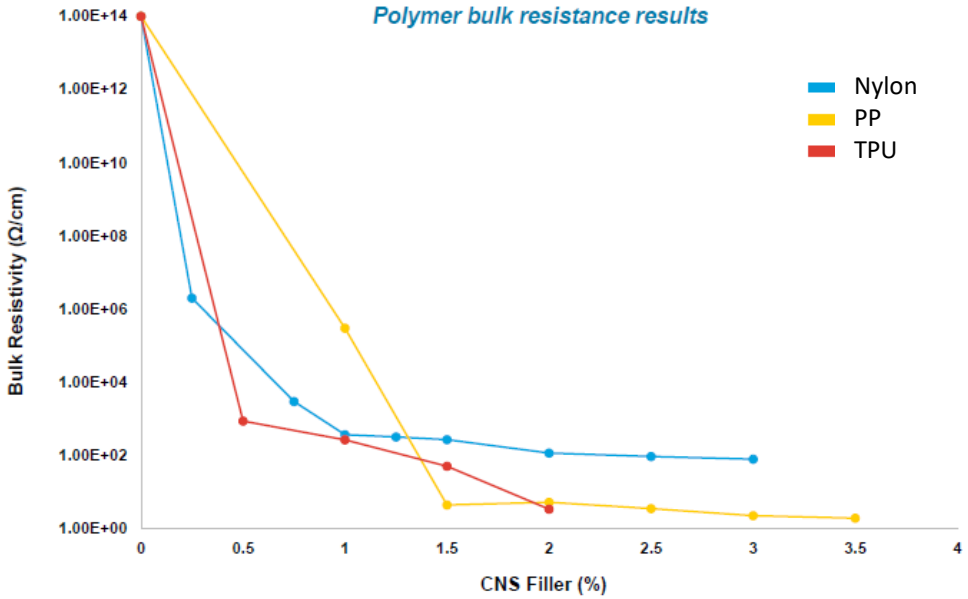
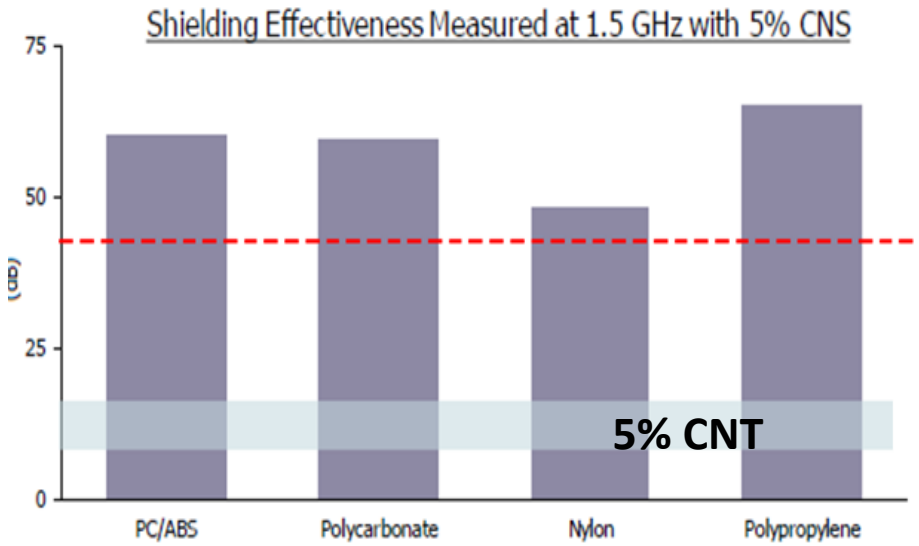
Carbon Nano Structures (CNS) is best-in-class carbon-based material for electrically conductive applications

Electrostatic Dissipation



- CNS based compounds demonstrate
  - Electrical percolation at 0.5% loading
  - Improvement in mechanical properties >100% improvements in tensile stress and 20-70% in tensile strength

EMI Shielding



- CNTs not currently used for EMI shielding
- CNS may enable broader adoption of carbons for EMI shielding opening up new market opportunities

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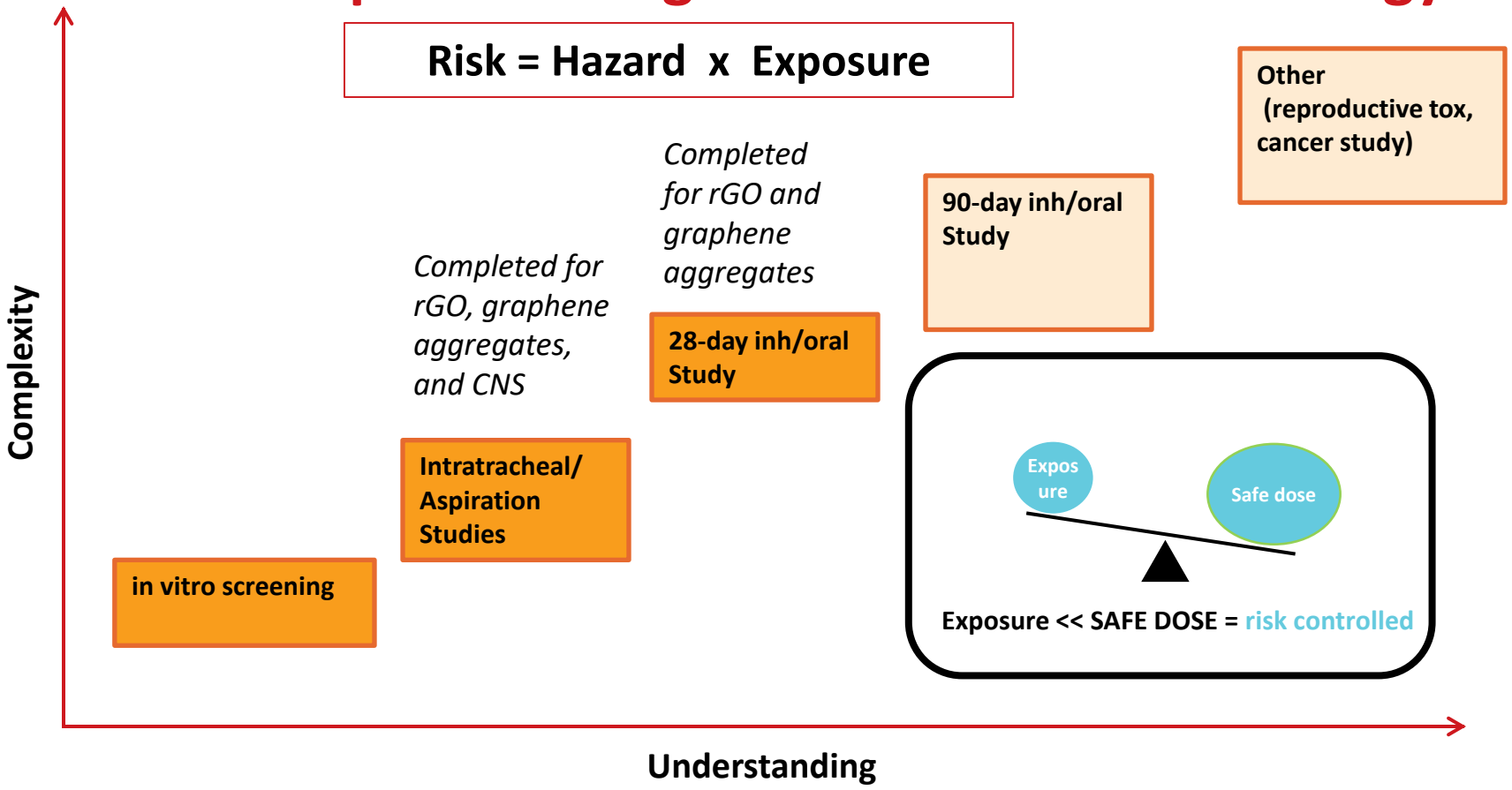
Managing risks associated with new materials- Roadmap of learning for new carbons toxicology



- Hazards of new materials are unknown. Minimize risk by minimizing exposure
- Develop understanding of hazards and exposures

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Challenges I

- Expanding product space leveraging high production volume platforms
  - Very high surface are (>400 m2/g) nonporous carbon black
  - Very low surface are (20 m2 /g) carbons in the furnace process
  - Expanding structure boundaries
    - Highly structured and unstructured CB and silica, aerogels
    - Narrow (σg<1.2) particle size distributions

- Measurements
  - Temperature, PSD measurements in the process

@ representative T, solids loadings and chemical environment

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Challenges II

- Processes based on sustainable raw materials with low C footprint
  - Large scale CH4 to carbon materials,
  - Bio derived or recycled feedstocks to carbon black and fumed silica
- Large scale cost effective processes for new fine particle materials
  - CNT, graphenes,
  - Metal and polymer powders for 3D printing
  - Surface modification in reactor and post process