Polymer Chemistry and the Building Blocks for Advanced Lithium-Ion Anode Materials

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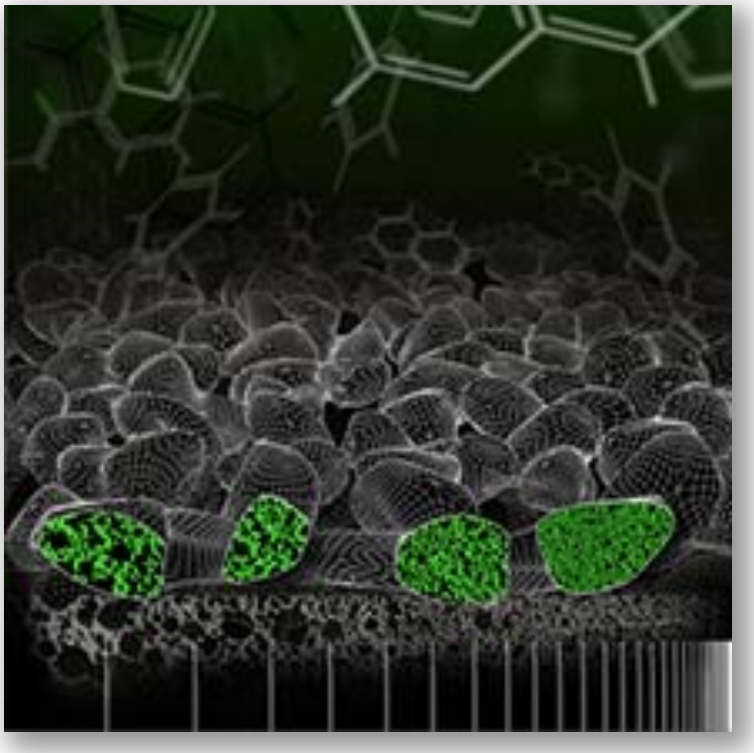
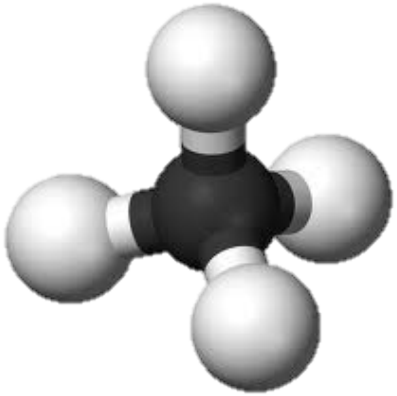
Company Highlights

- Commercial sales of best ultracapacitor carbon available
- Lead-acid additive dramatically improves micro-hybrid performance
- New silicon-carbon nanocomposite for Li-ion anodes
- Collaboration agreements with Fortune 50 strategic partners
- Full scale manufacturing with ISO 9001 and ISO 14001 certification
- Broad IP portfolio including material, device performance, and manufacturing
- Board of Directors includes Bob Lutz, former Vice-Chairman GM, CEO Exide



Polymer Chemistry Enables a Flexible Platform



Adsorbed Gas

Ultracapacitors

Enhanced Lead Acid

enerG2
NEXT GENERATION ENERGY STORAGE

Advanced Batteries

Lithium Ion Anodes

Asymmetric Capacitors

EnerG2 is not just high performance materials, but a flexible energy storage technology platform built for continuous advancement.

Polymer Chemistry Drives Carbon Performance

Typical Precursors:

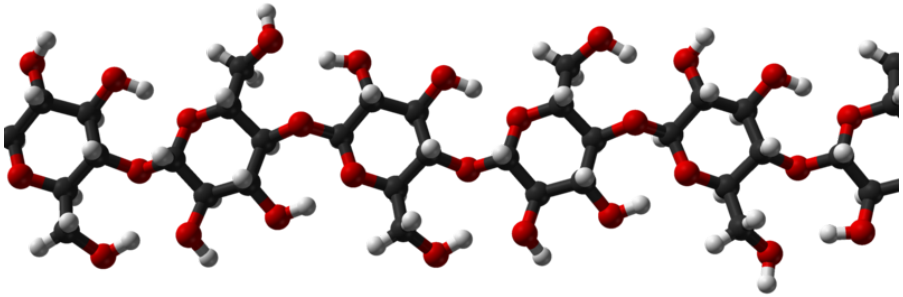
- Agricultural Waste
- Petroleum byproducts
- Scrap wood products

Carbonized

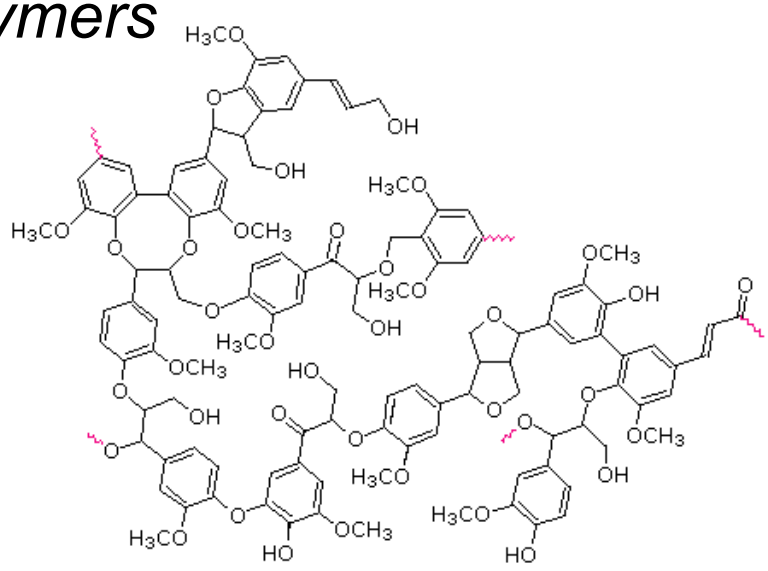
Problems:

- High impurities
- Inconsistent
- Not optimized
- Low yield

The two most prevalent natural polymers



Cellulose



Lignin

Polymer Chemistry Drives Carbon Performance

Typical Precursors:
- Agricultural Waste
- Petroleum byproducts
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Carbonized

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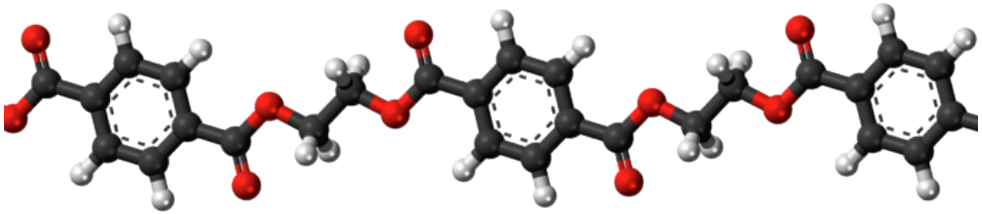
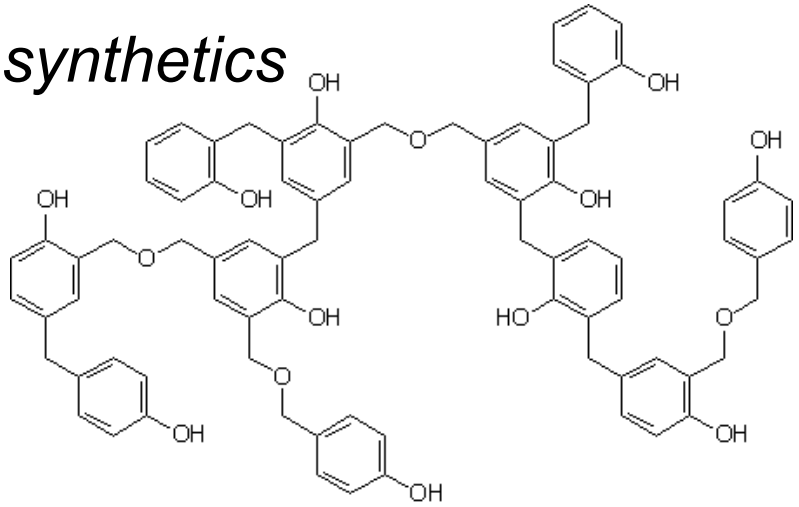
A couple of similarly structured synthetics



Polyethylene terephthalate
- PET



Phenolic Resin
– Wood Glue

Polymer Chemistry Drives Carbon Performance

Typical Precursors:
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Carbonized

Problems:
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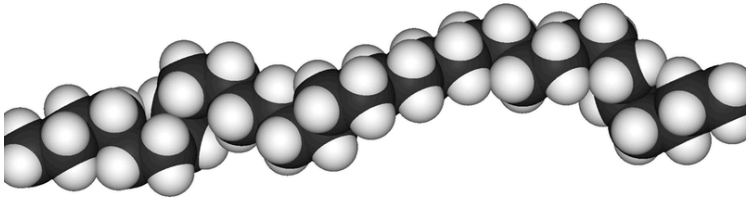
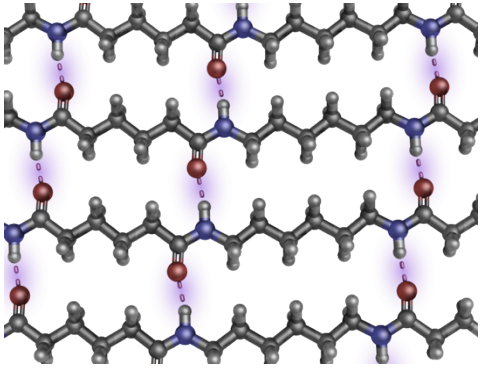
- Low yield

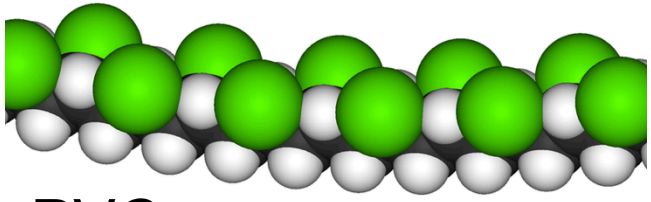
The options are virtually limitless



Polyethylene



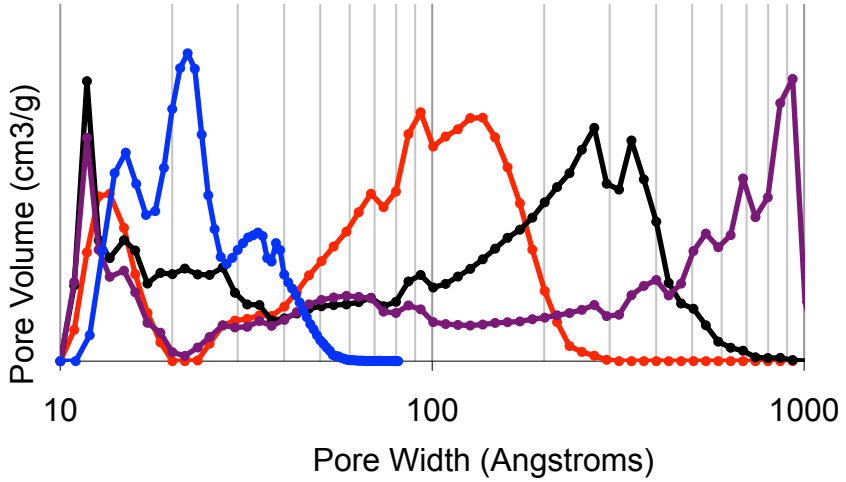
Nylon



PVC

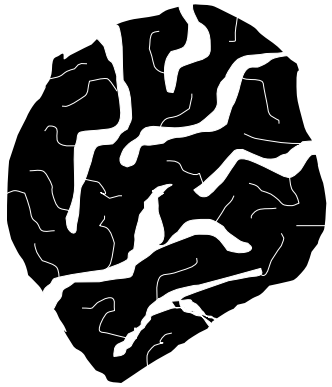
We Can Optimize for a Range of Applications

- Polymer chemistry derived platform allows for the tailoring of:
  - Pore size distribution
  - Total pore volume
  - Specific surface area
  - Amorphous carbon bonding and structure
  - *Strategic incorporation of dopants like silicon*

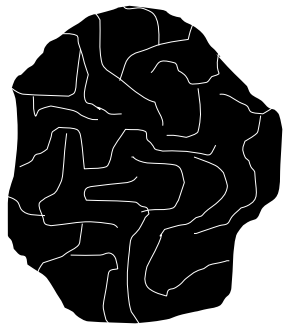


Lead Acid

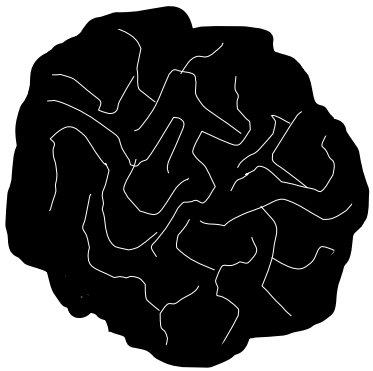
Ultracap Power



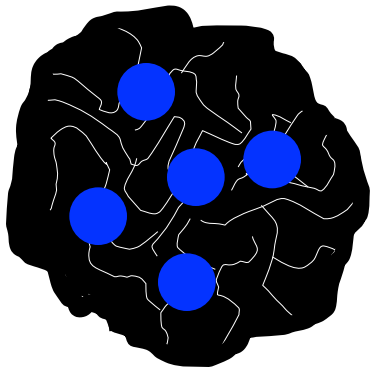
Ultracap Energy + ANG



Lithium Hard Carbon



Lithium Silicon - Carbon

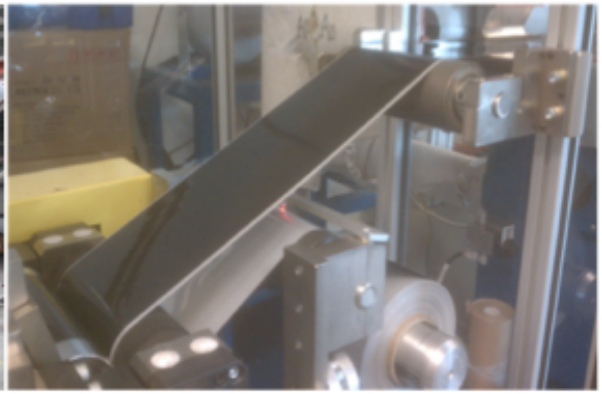


Platform Enhances Performance Across Applications

- Ultracapacitors
  - Commercially deployed energy and power carbon
  - Carbon of choice for 3V rating – multiple programs ready to enter into the market
- Lead Acid Batteries
  - Increased charge acceptance and cycle life for micro hybrids
  - Validated in deep discharge duty cycle
  - Demonstrated improvement in hybrid battery - capacitor
- Lithium Ion
  - High capacity hard carbon enhances rate performance
  - Silicon-carbon nanocomposite with validated cycle stability
- Adsorbed Natural Gas Storage
  - Best in class carbon at ton scale for low pressure storage of NG in conformable tanks

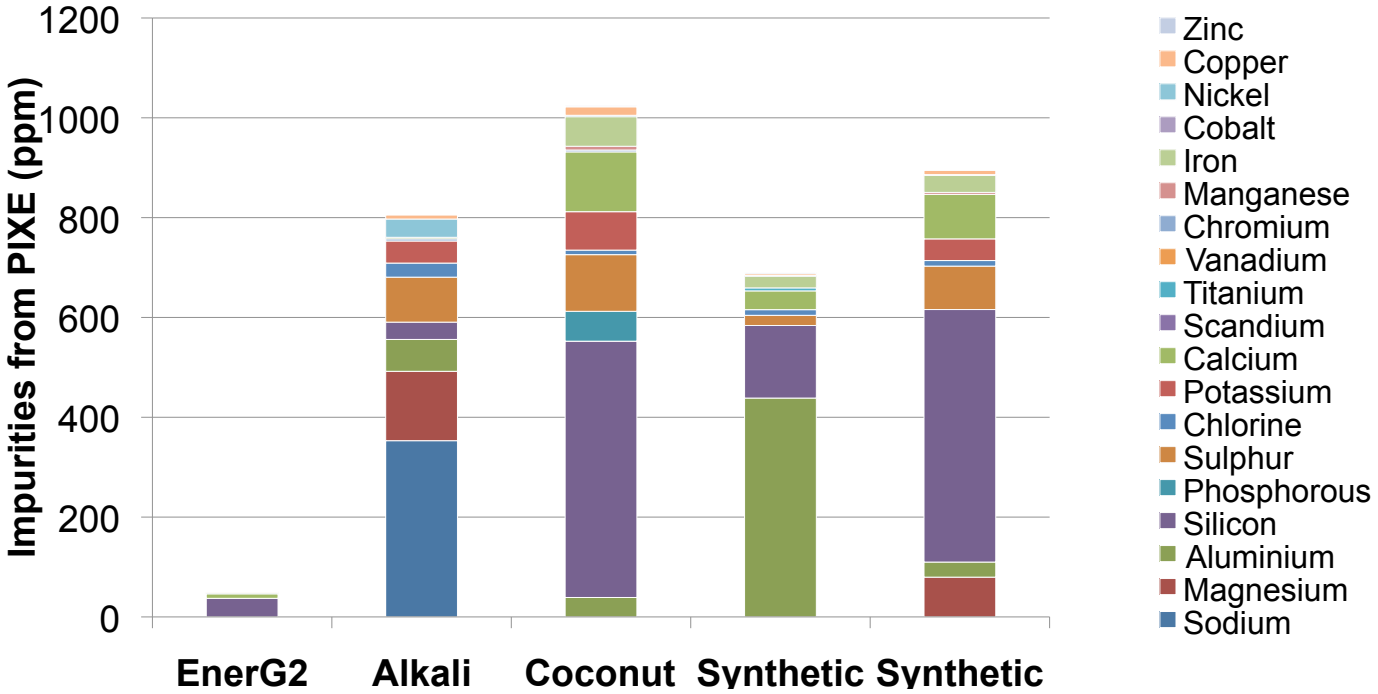
Manufacturing: Producing at Scale

- Ultracap and Lead-acid products at full commercial scale
- ISO 9001, ISO 14001 Certified
- Capacity 20-40 MT/month, producing ~2 MT/month currently
- Can grow capacity 4X within footprint – 80-160 MT/month
- Hard carbon/Si-C platforms in scale up now

Impurities of Various Energy Storage Carbons

EnerG2 carbon has **less than 1/20th** of the impurities that are found the best commercial carbons:



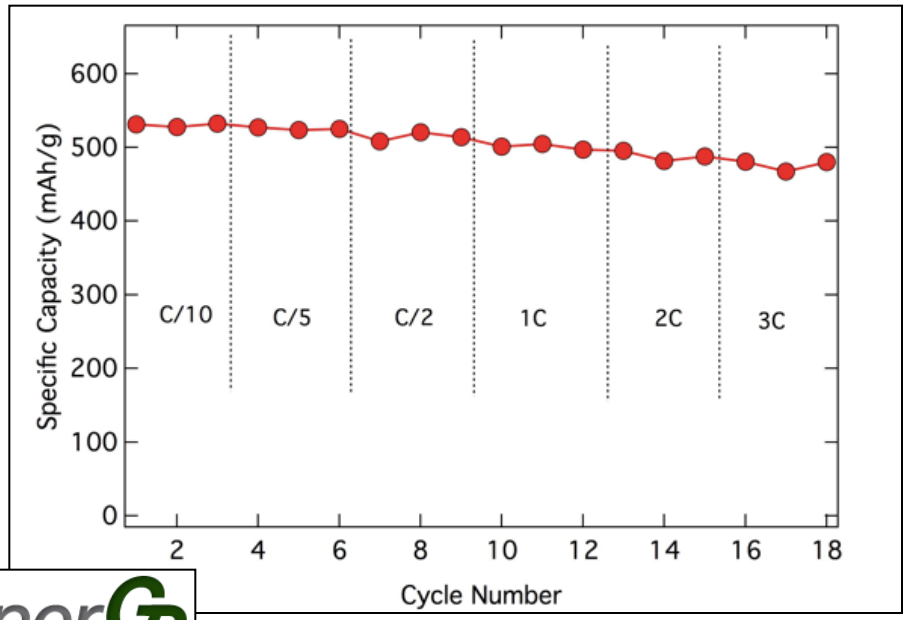
***Update**: Patent number 8,404,384 issued*
– covering high surface area carbons with less than 500ppm of impurities.

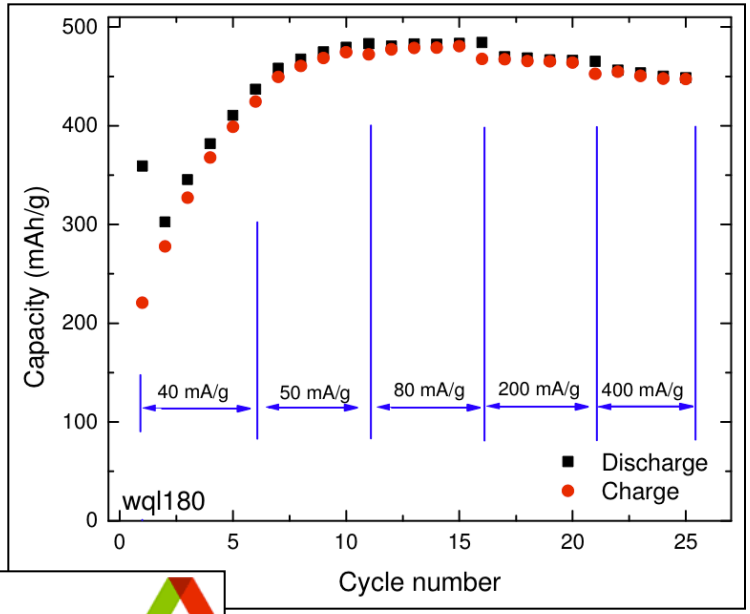
Improvements Needed in Li-ion Anodes

- Advancements in cathode such as LRNMC have not been matched by anodes
- Graphite anodes have reached maximum capacity
- Certain applications require more power
- Need to maintain:
  - Cycle life
  - Safety
  - Process-ability
  - Cost
- Massive scale required to support industry

Hard Carbon Attributes

- EnerG2 hard carbon is a superior platform for a silicon support matrix
  - >500 mAh/g reversible capacity
  - 85% first cycle efficiency
  - Excellent rate performance: 93% capacity retention (2C/0.1C)
  - *Interesting opportunity to incorporate Si*





Silicon Anode Issues

Micro-Silicon	Nano-Silicon
❑ Highly fractured after cycling	❑ Poor electrode conductivity after cycling
❑ SEI layer instability	❑ Poor process-ability
❑ Low capacity after cycling	❑ Low volumetric energy density
❑ Low coulombic efficiency	❑ Excessive carbon black required

EnerG2 Silicon Solutions

Micro-Silicon	Nano-Silicon
✓ Highly fractured after cycling	✓ Poor electrode conductivity after cycling
✓ SEI layer instability	✓ Poor process-ability
✓ Low capacity after cycling	✓ Low volumetric energy density
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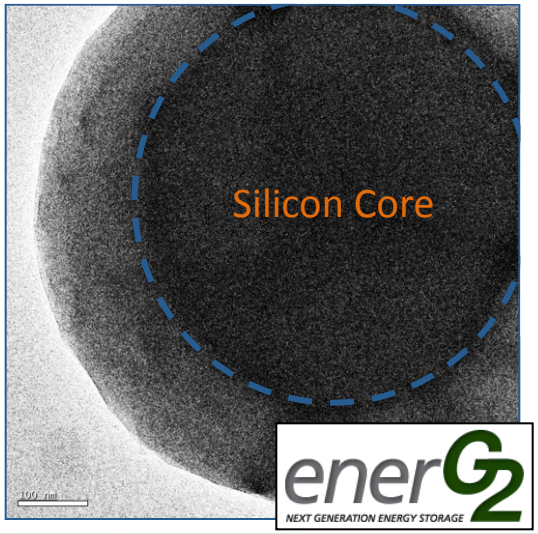
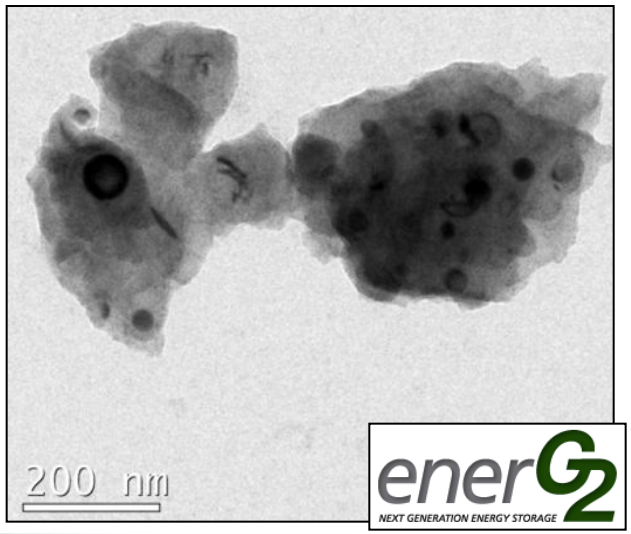
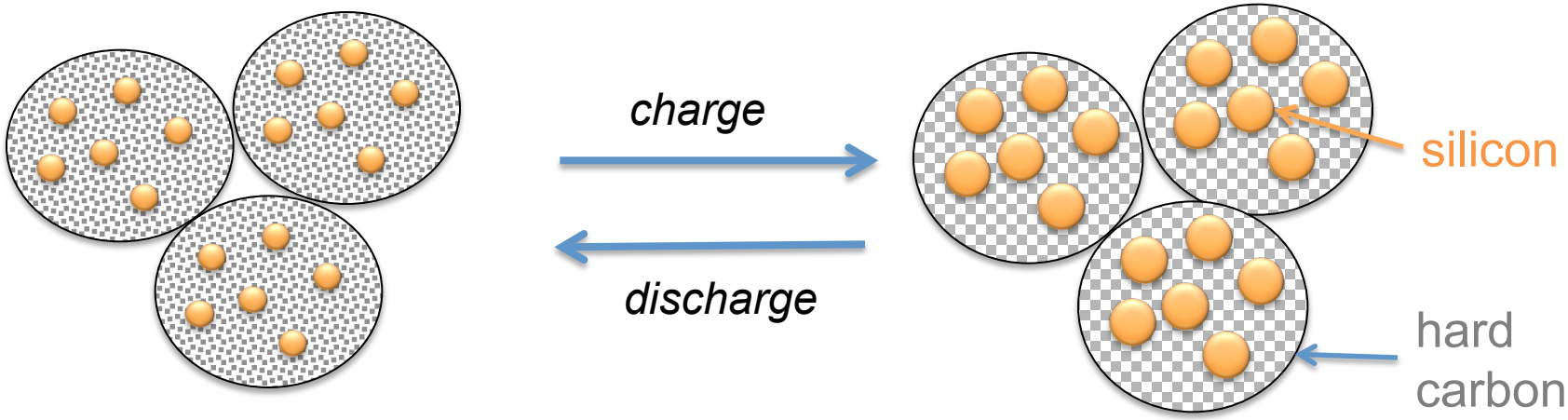




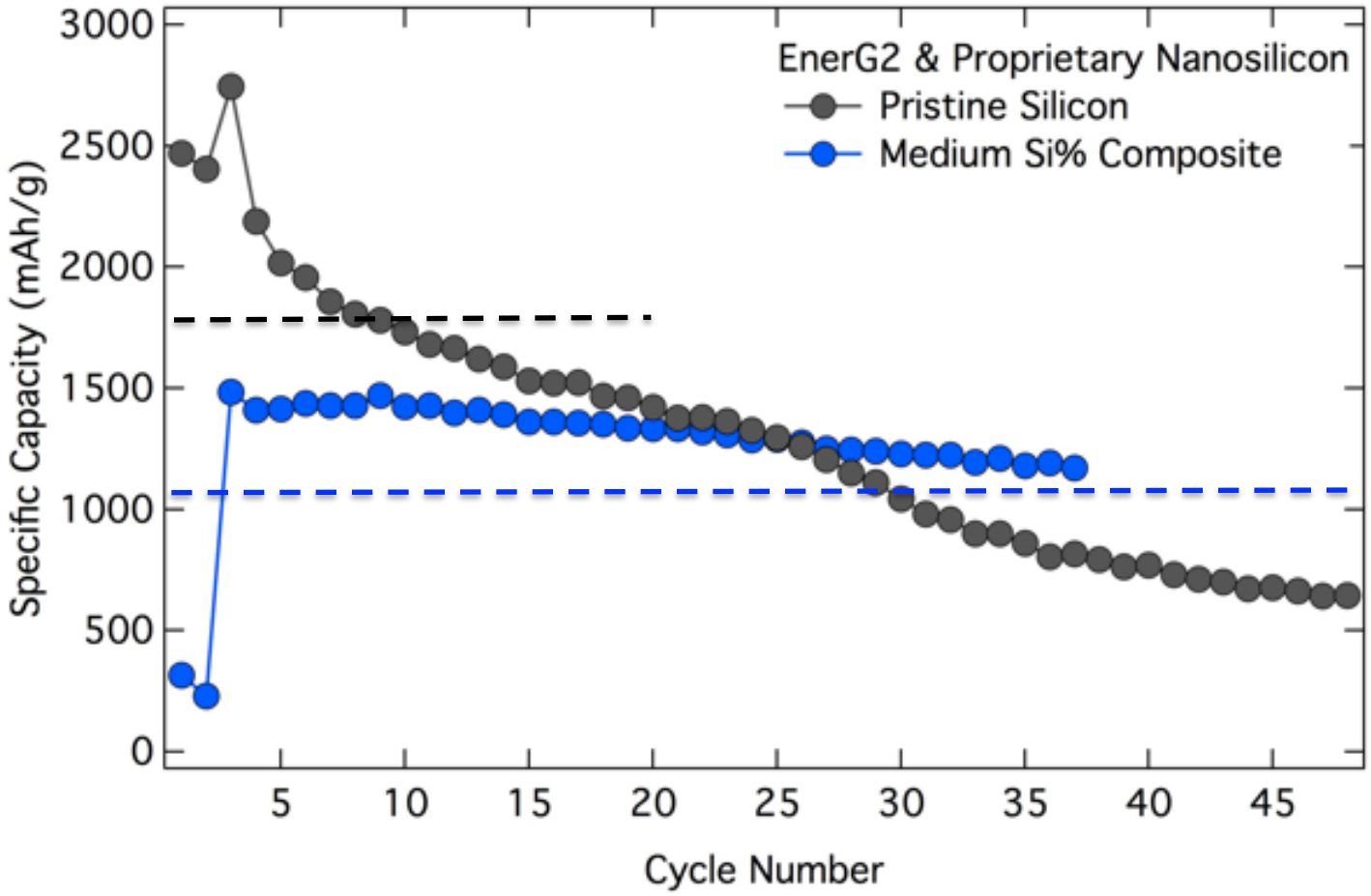
The Function of the Si-C EnerG2 Technology



- 5-10X improvement in silicon cycle life
- Lower density hard carbon allows silicon expansion
- Excellent silicon-carbon bonding
- Minimizes issues with silicon expansion and contraction
- Enables reversible lithium storage in nano-silicon
- 85% FCE - Stable SEI on carbon vs. silicon
- Electrode processing typical of carbon

Compatible With Numerous Silicon Materials #1

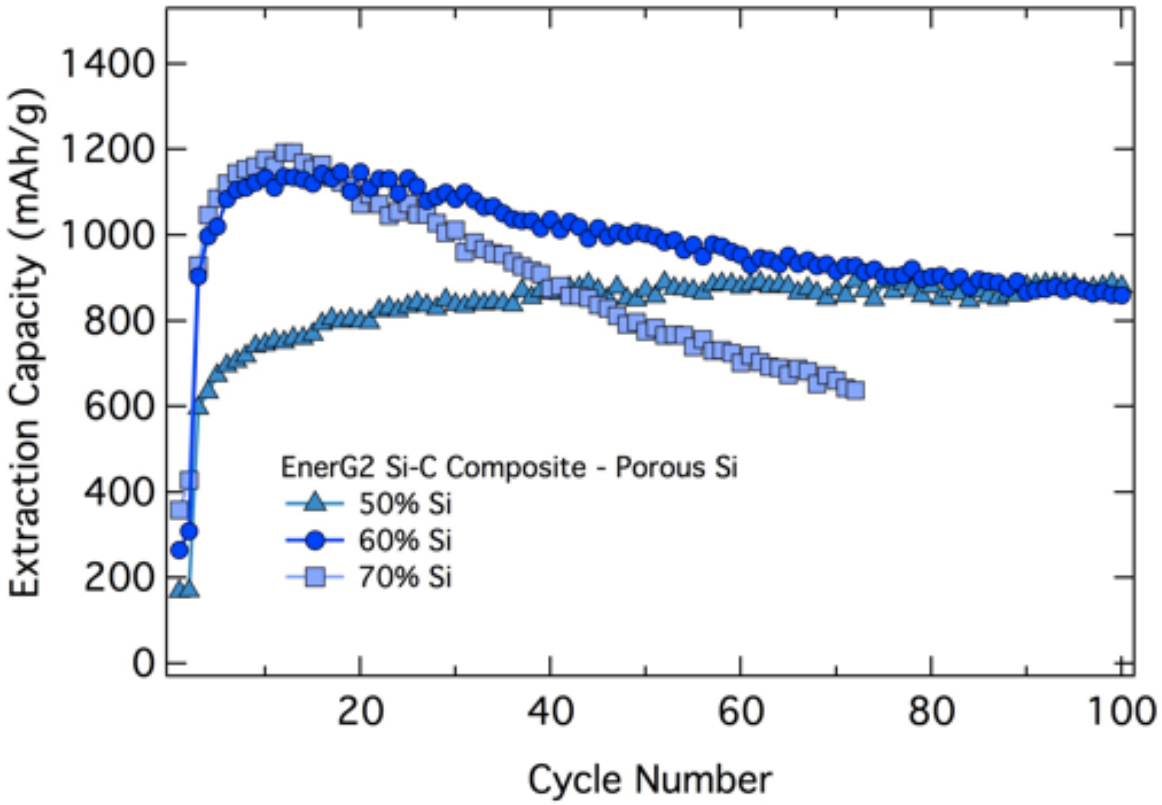
- Nano-silicon shows improved cycle life over micron-sized silicon materials
- EnerG2 nanocomposite yields **>5x increase in cycle life** over pristine Si



80% retention

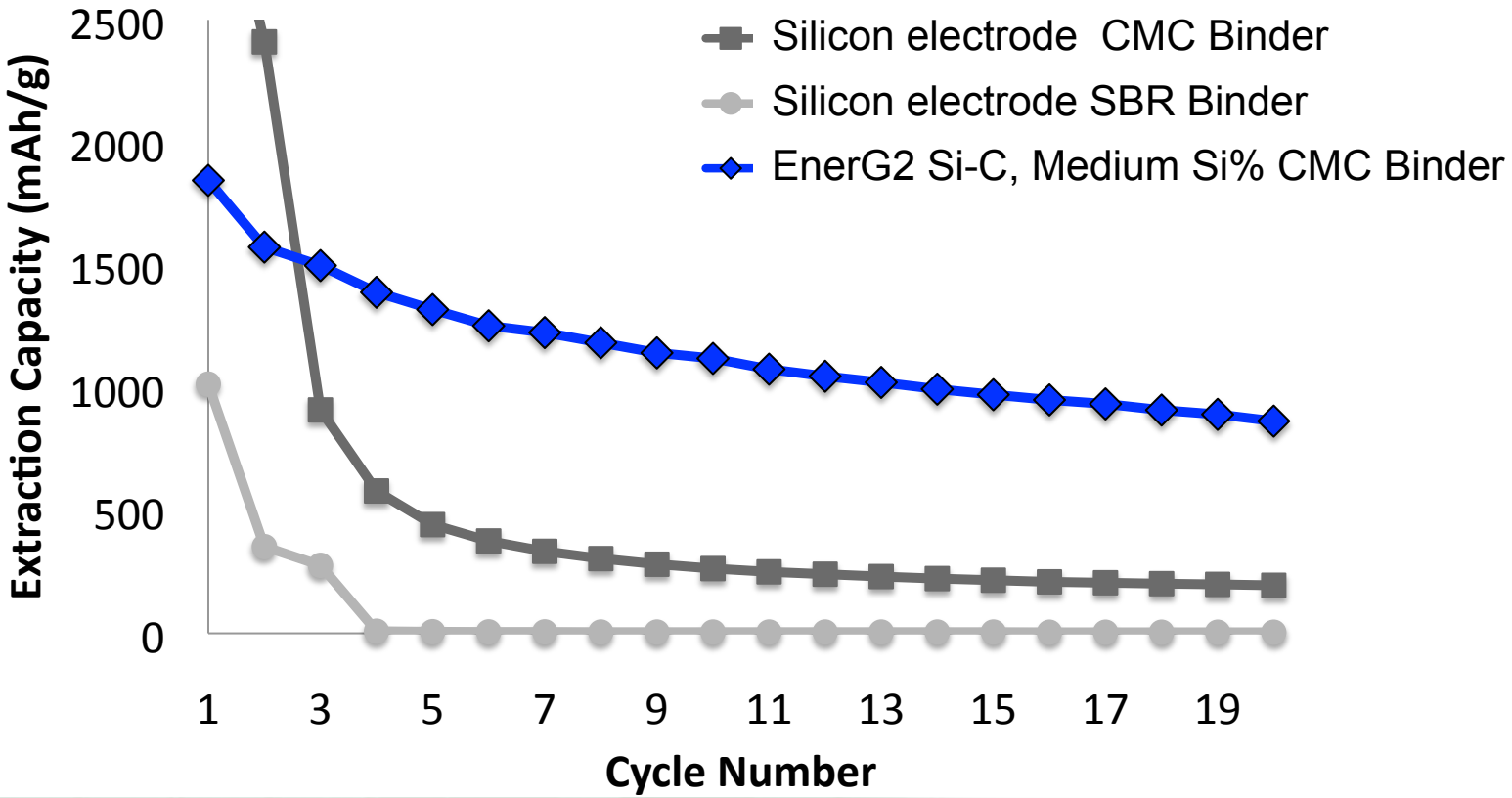
Compatible With Numerous Silicon Materials #2

- Materials with silicon content from 10-90% have been cycled successfully – tradeoff between Si content and stability
- This lower cost silicon was very difficult to process without carbon modification



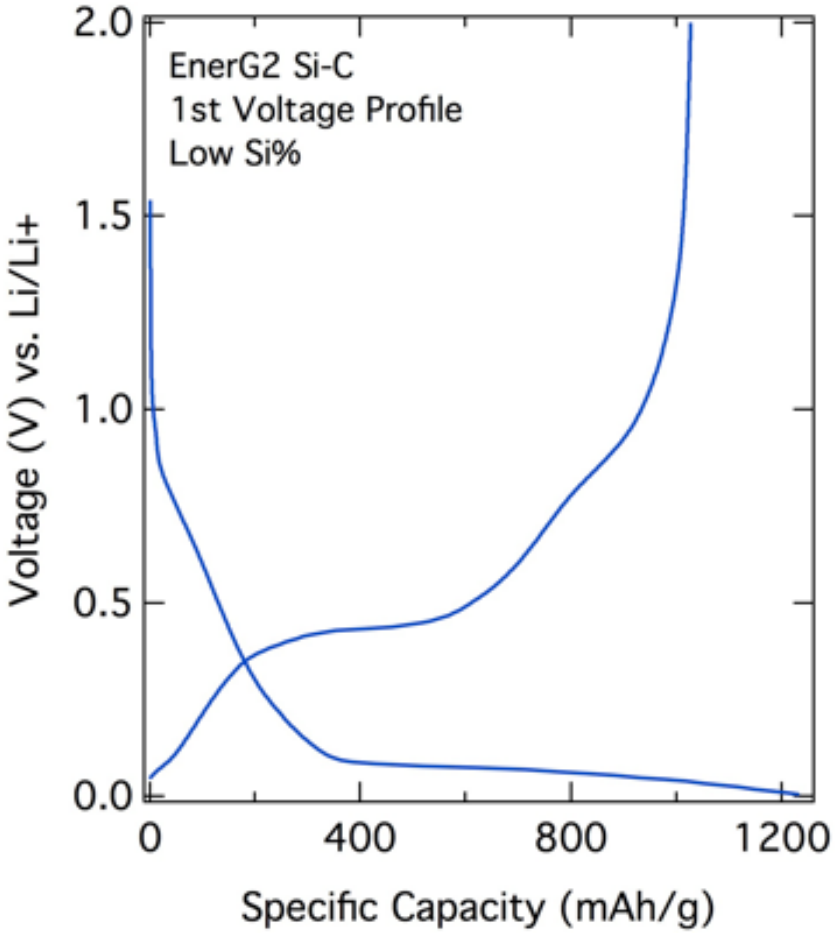
Compatible With Numerous Silicon Materials #3

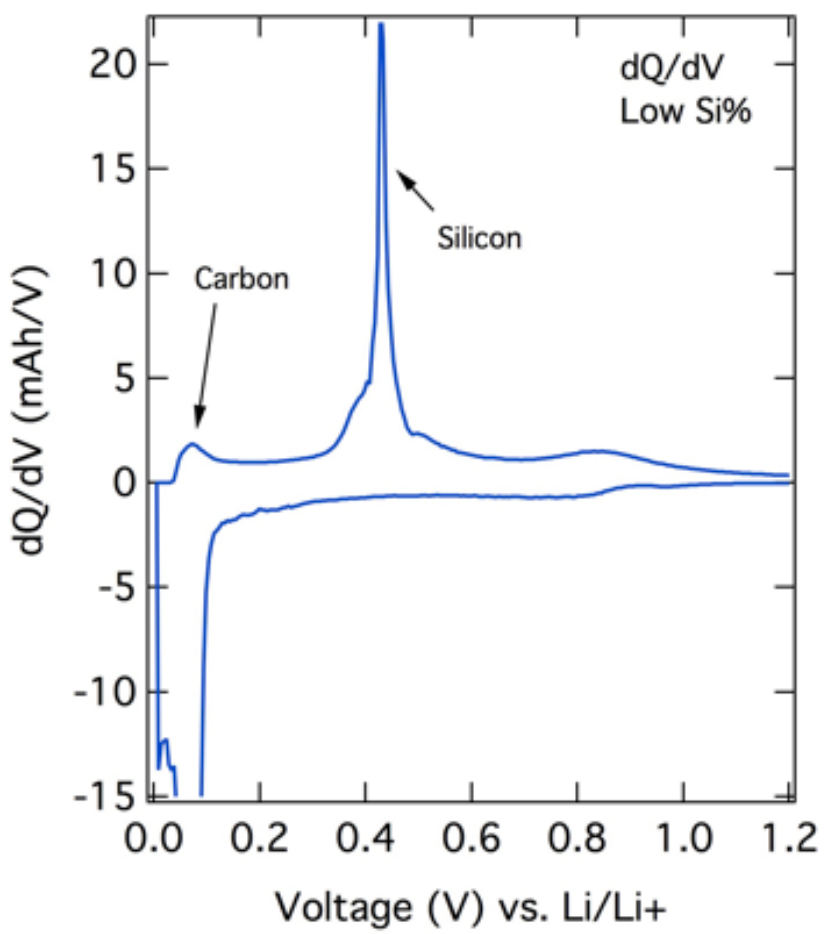
- EnerG2 Nanocomposite is most compatible with CMC Binder
- PVDF binders are not recommended for use with silicon materials



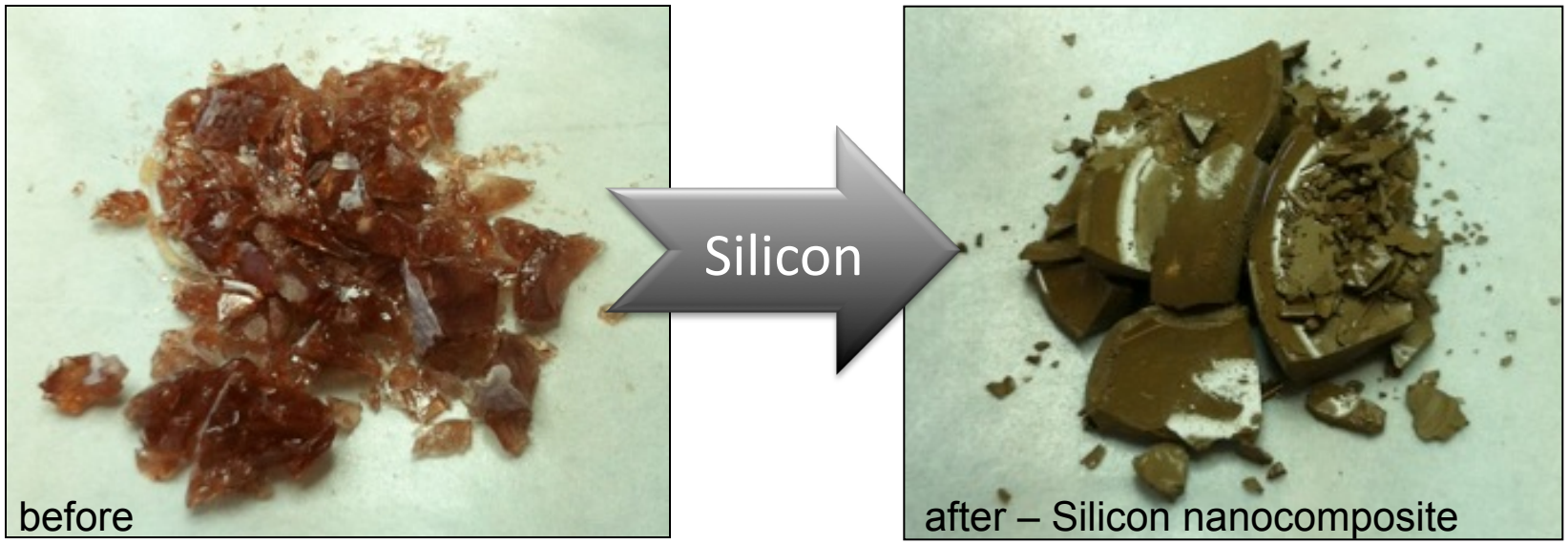
Si-C Composite Electrochemical Features

- Exhibits attributes of carbon and silicon





Incorporation of Silicon at the Resin Stage



- Drop-in manufacturability for rapid scale-up of any silicon
- Customizable silicon content to meet or exceed customer needs
- Silicon + Carbon co-processing produces cohesive nanocomposite
  - Excellent Silicon-Carbon bond

100+ kg resin production run

Si-C Timeline

- Rapid Manufacturing scale-up
- Range of lab, pilot, and full scale equipment
- Established transitions

- Lab Scale
- 1-100g
- Q4 2013

- Pilot Scale
- 1-10kg
- Q1 2014

- Full Scale
- 100+kg – multi-ton
- Q2 2014

Thank You

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