Recovery of Carbon Products from Coal Ash

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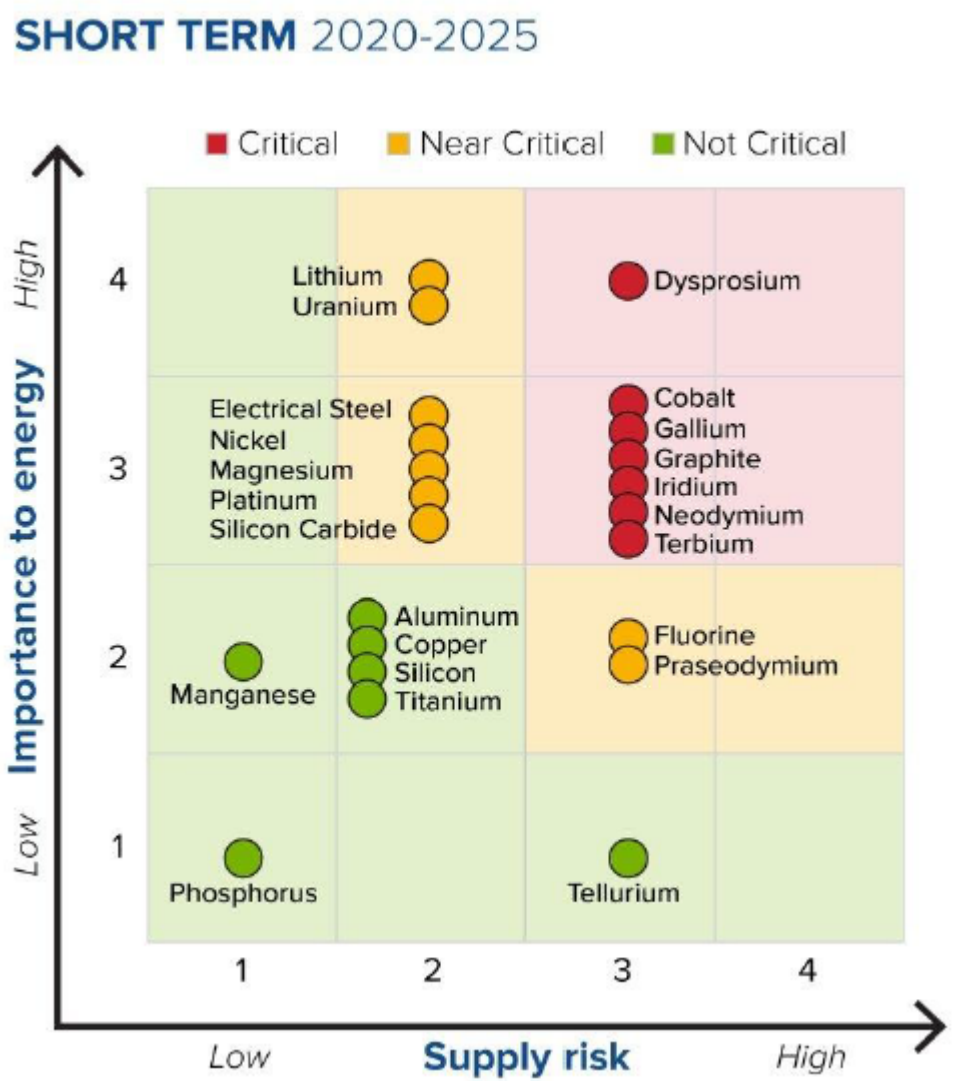
Evolve Central Appalachia (Evolve CAPP) Open Session
Julian, WV – August 4th, 2023

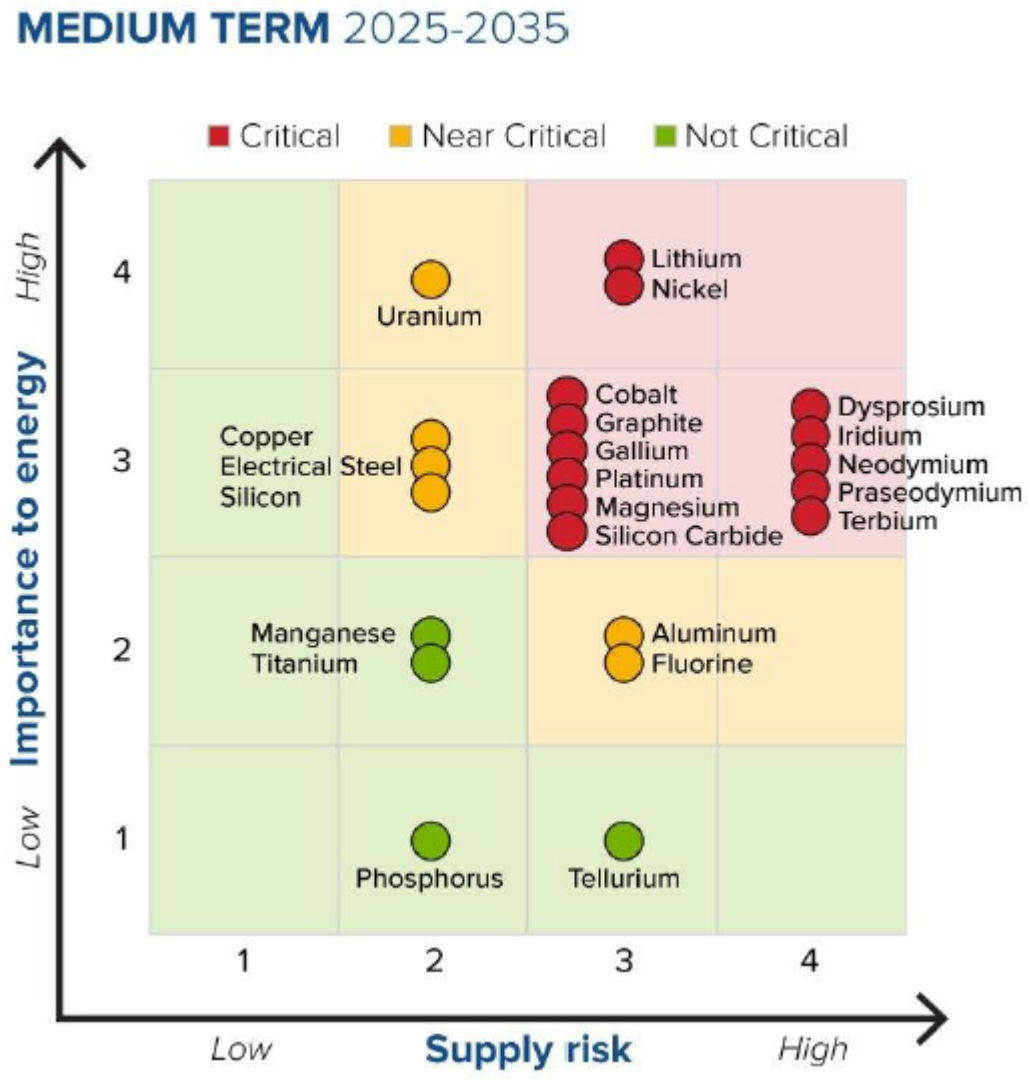
ACKNOWLEDGEMENT

This material is based upon work supported by the Department of Energy under Award Number DE-FE0032055.

DISCLAIMER

What are Critical Materials and Critical Minerals?

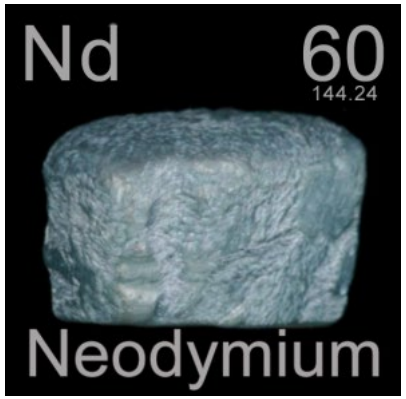


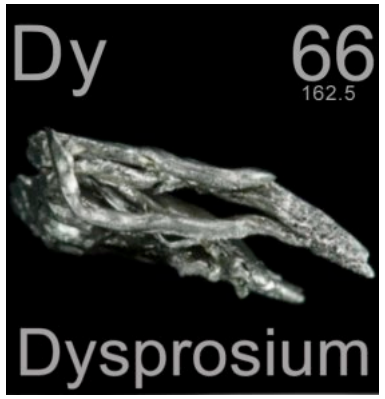


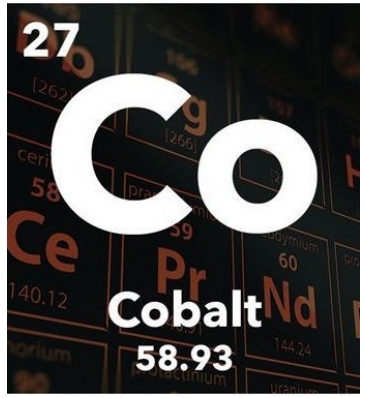
U.S. Department of Energy Releases 2023 Critical Materials Assessment to Evaluate Supply Chain Security for Clean Energy Technologies, July 31, 2023

Critical Materials Institute (CMI) – An Energy Innovation Hub

- To assure supply chains of materials critical to clean energy technologies,
- Enabling innovation in US manufacturing, and
- Enhancing US energy security.







Nd,Dy-Fe-B; Sm-Co

- **No NdFeB magnet manufacturing companies in US**
- **90% rare earth world supply in China**

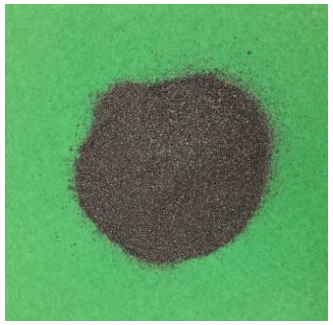
OAK RIDGE National Laboratory

https://cmi.ameslab.gov/

CMI Critical Materials Institute AN ENERGY INNOVATION HUB

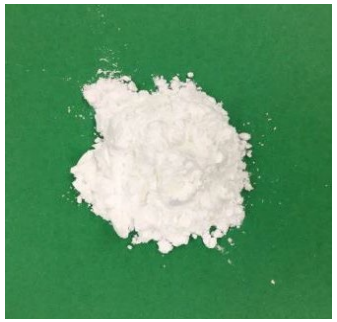
Big Area Additive Manufacturing (BAAM) Process for Critical Rare Earth Magnets

MQA anisotropic powder



+

Nylon-12

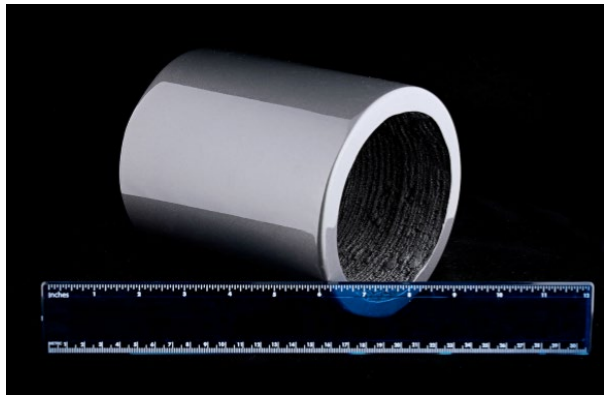


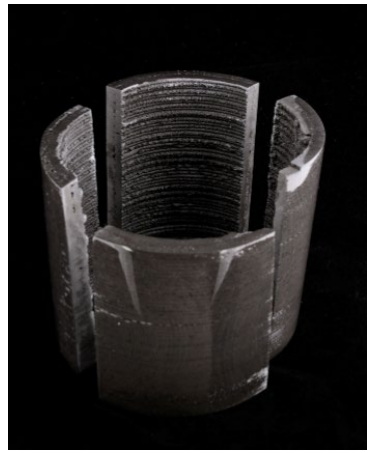
Mix, melt and extrude

Composite pellets: 70 vol % MQA+ Nylon

BAAM printing

Additively printed NdFeB bonded magnets



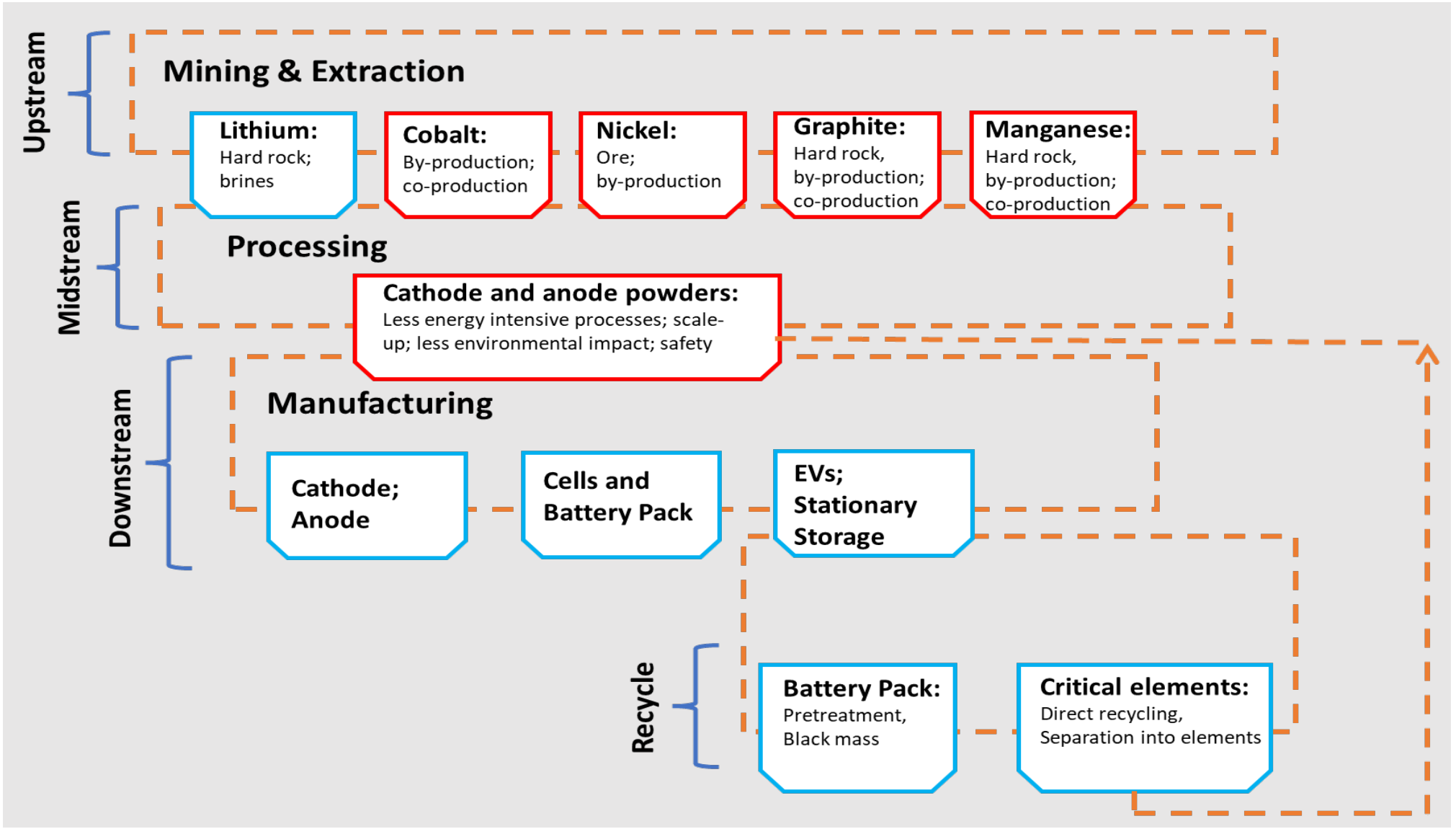


R&D 100

https://web.ornl.gov/sci/manufacturing/mdf/

Li, L. *et al., Sci. Rep.* 6, 36212 (2016); *Additive Manuf.* 21, 495 (2018)
Magnetic Moments, The Economist, Nov. 19, 2016; K. Gandha et al., J MMM (2019); Scripta Materialia (2020)
Frontiers of Materials Research 2019 (National Academy of Sciences; p.2-26)

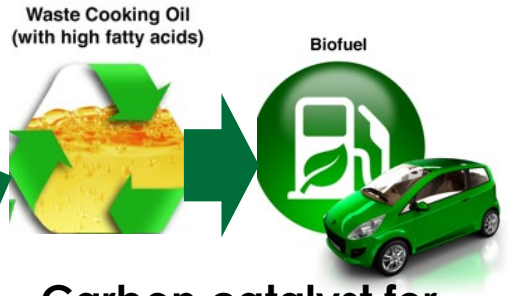
Critical material supply chain for lithium-ion batteries with some capacity and gaps on a globally competitive scales



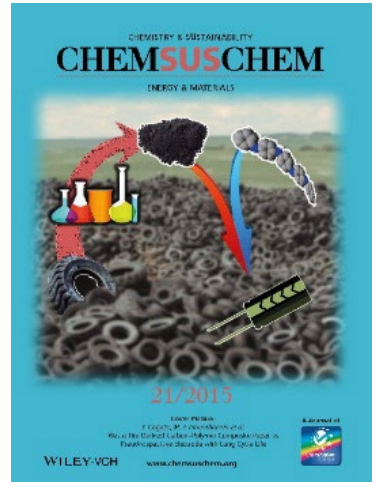
EERE Battery Critical Materials RFI Workshop Report, 2021. Battery Critical Materials Supply Chain – challenges and opportunities, U.S. Department of Energy, Energy Efficiency and Renewable Energy

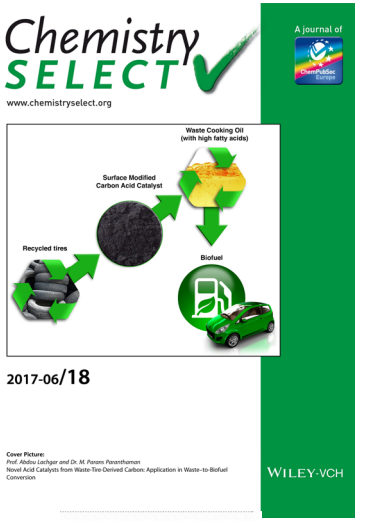
Recovery of Carbon from Recycled Tires for Clean Energy Applications

Electrodes for grid storage batteries and supercapacitors



Carbon catalyst for converting waste cooking oils into biodiesel





Electrodes for EV cars

Catalyst – Fuel cell; water desalination (capacitive deionization, selenium, arsenic removal)

OAK RIDGE National Laboratory **Journal Publications:** 12 ; US Patents 7 (+3 (Patent applications)); Inventions: +3

R&D 100

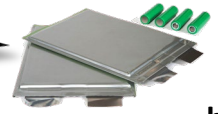
Carbon Ore and Coal Refuse-to-Products Project at ORNL's CFTF in collaboration with University of Kentucky

Coal Refuse

Coal-Derived Pitch Processing

Coal Char

Graphite Powder



Li-ion batteries

Not all coals are the same

Electrochemical Graphitization

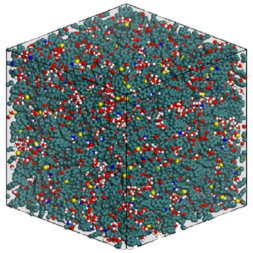
particles

graphitized particles

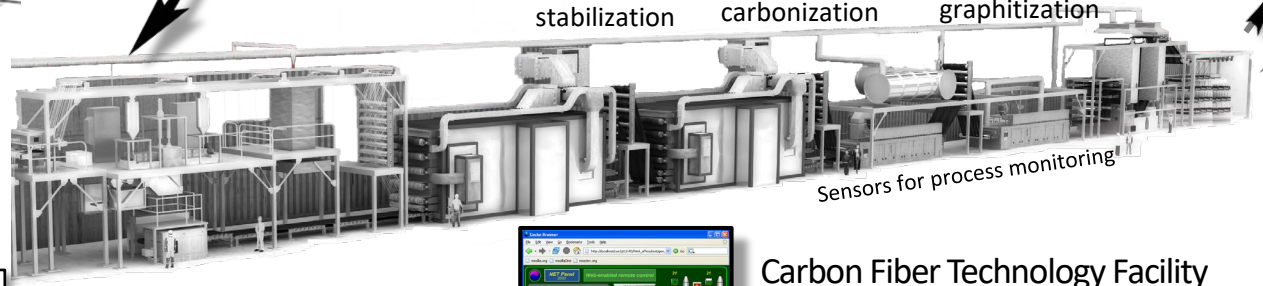
Continuous carbon fibers for structural applications

Composite Materials and Structures

86.6 Å



stabilization carbonization graphitization



Sensors for process monitoring

Short carbon fibers for structural applications

Molecular Structure of Coal

High-throughput characterization tools will be used to determine the molecular structure of any type of coal.

Melt spinning or melt blowing pitch into fibers, or spray drying pitch into particles

Process Control

Carbon Fiber Technology Facility settings are selected based on the nature of the feedstock and desired final product

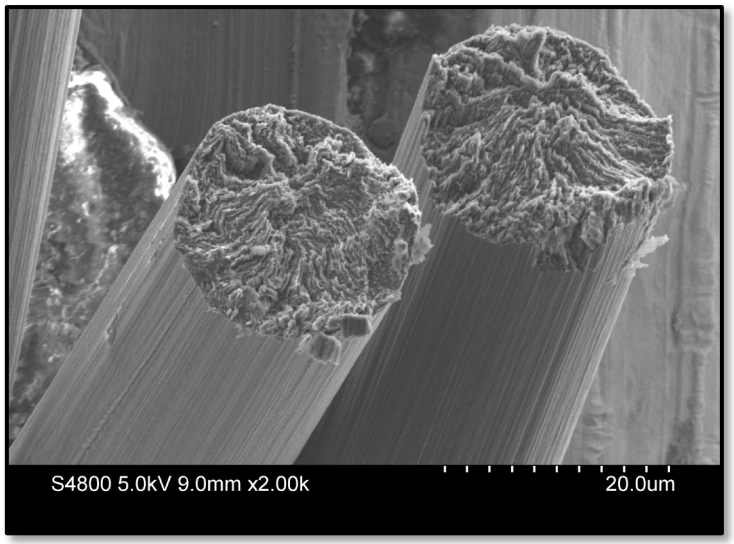
Short carbon fibers for thermal insulation

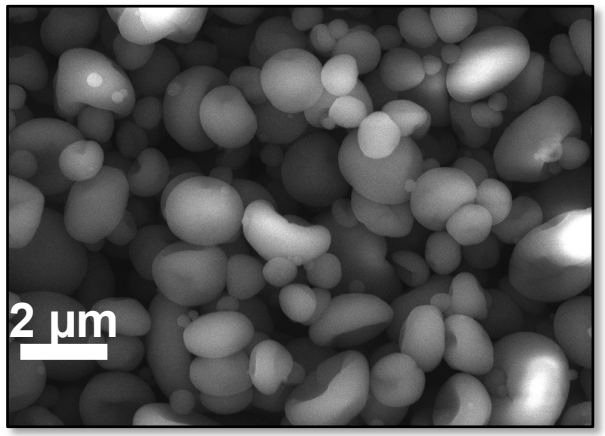
Tech-to-Market

Lara-Curzio (2021)

Scale up Production of Fibers and Graphite from Carbon Ore and Coal Refuse

Waste coal (underflow) was collected from the Alliance Resource Partners River View Mining Complex in Uniontown, KY, which is currently extracting coal from the Springfield (Western Kentucky #9) seam.



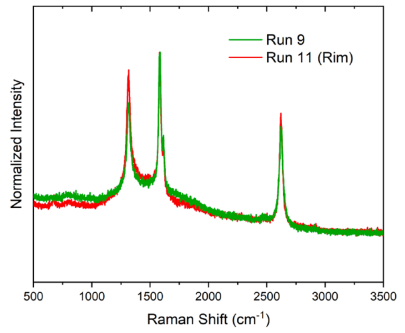


University of Kentucky produces graphite fibers from waste coal

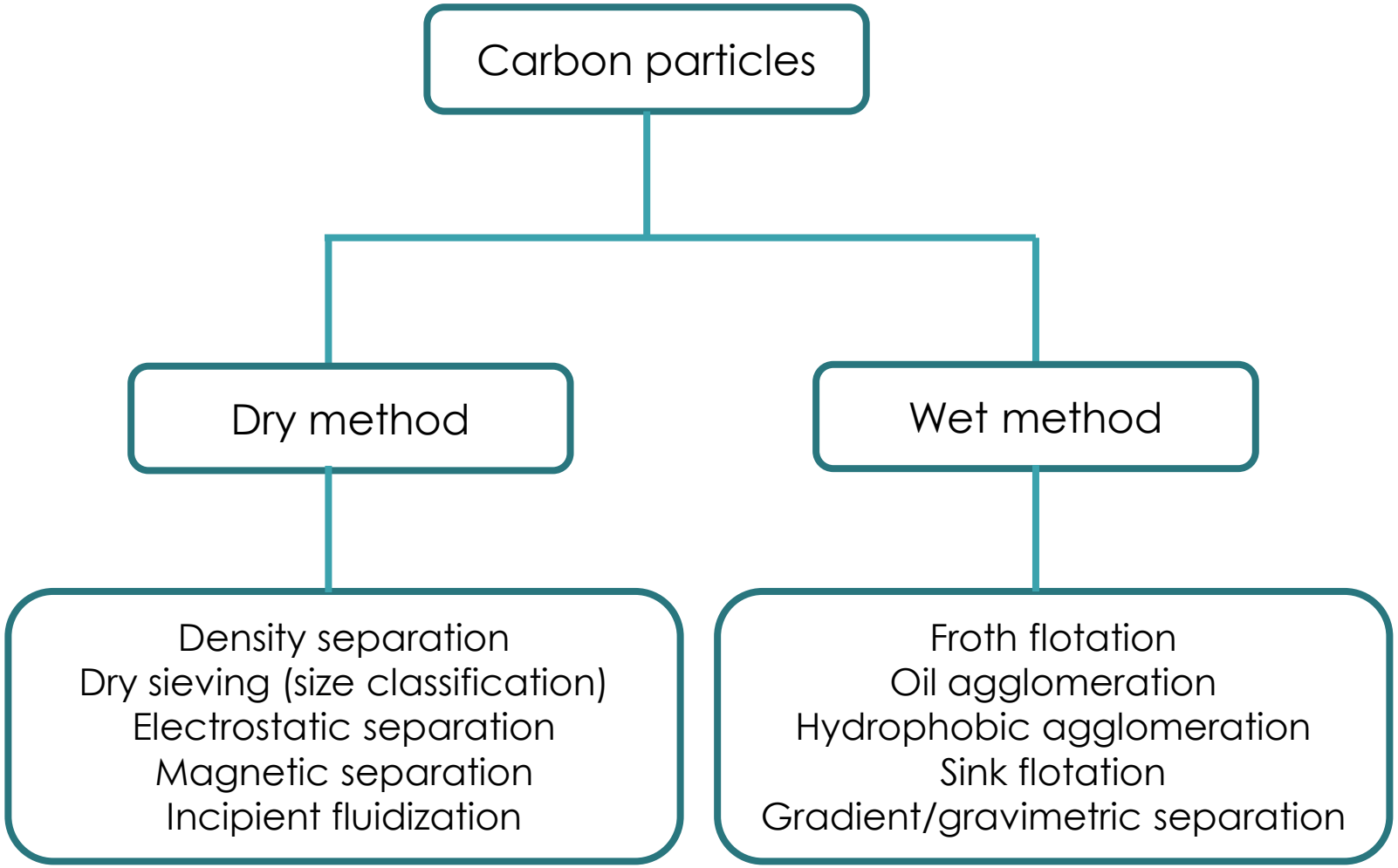
Young's Modulus: 550 ± 152 GPa
Tensile Strength: 1,424 ± 540 GPa
Strain at Failure: 0.262 ± 0.090 %

Breakthroughs!

ORNL produces electrochemically graphitized particles from coal for Li-ion battery anodes



Flow-chart for the dry and wet method for the separation of coal from coal ash



(Alam et al. 2021)

Recovery of Carbon from Coal Ash for Clean Energy Applications

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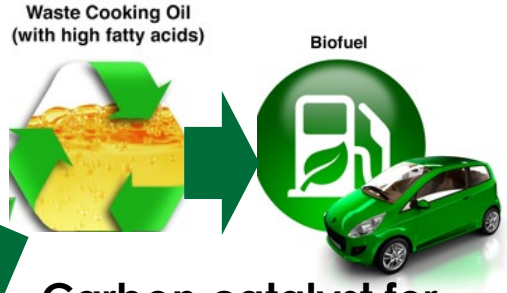

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Carbon Electrodes for EV cars

Carbon for high value products