

FE0032313



C4Ward@Scale

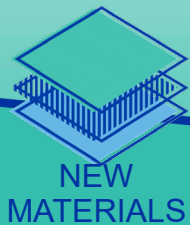
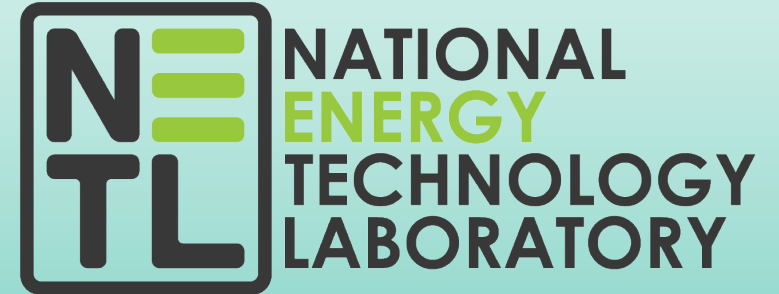
Scaled-Up Coal Conversion for Carbon Fibers and Graphite

Matthew Weisenberger

2024 NETL Resource Sustainability Annual Project Review Meeting: 2- 4 April 2024



U.S. DEPARTMENT OF
ENERGY



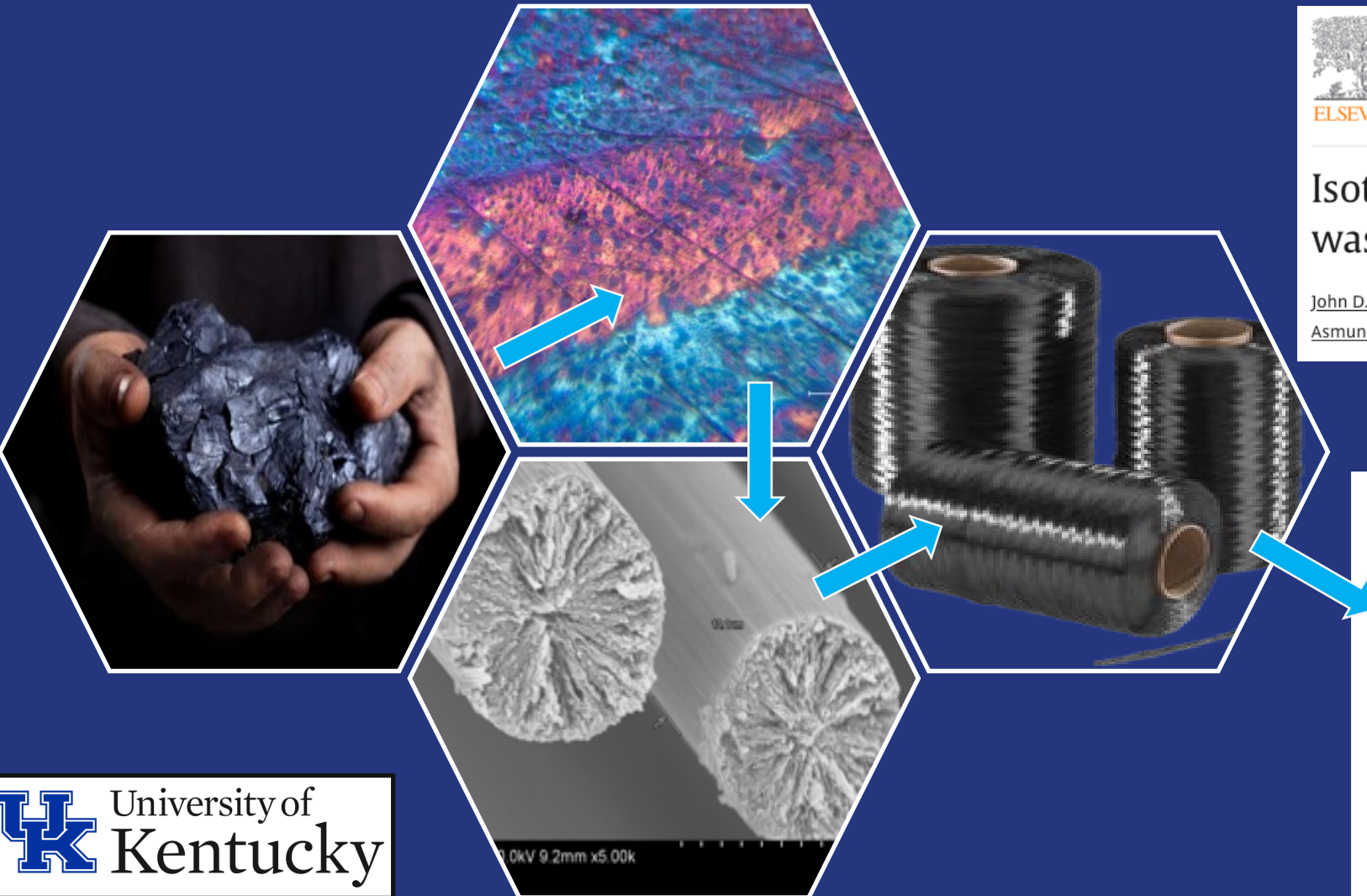
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TECHNOLOGY BACKGROUND



Coal Derived Carbon Fiber Production

Prior work started:
Summer 2020



 **Carbon**
Volume 216, 5 January 2024, 118590 

Isotropic pitch-derived carbon fiber from waste coal

John D. Craddock  , George Frank, Michela Martinelli, Justin Lacy, Vivian Edwards, Asmund Vego, Christina Thompson, Rodney Andrews, Matthew C. Weisenberger

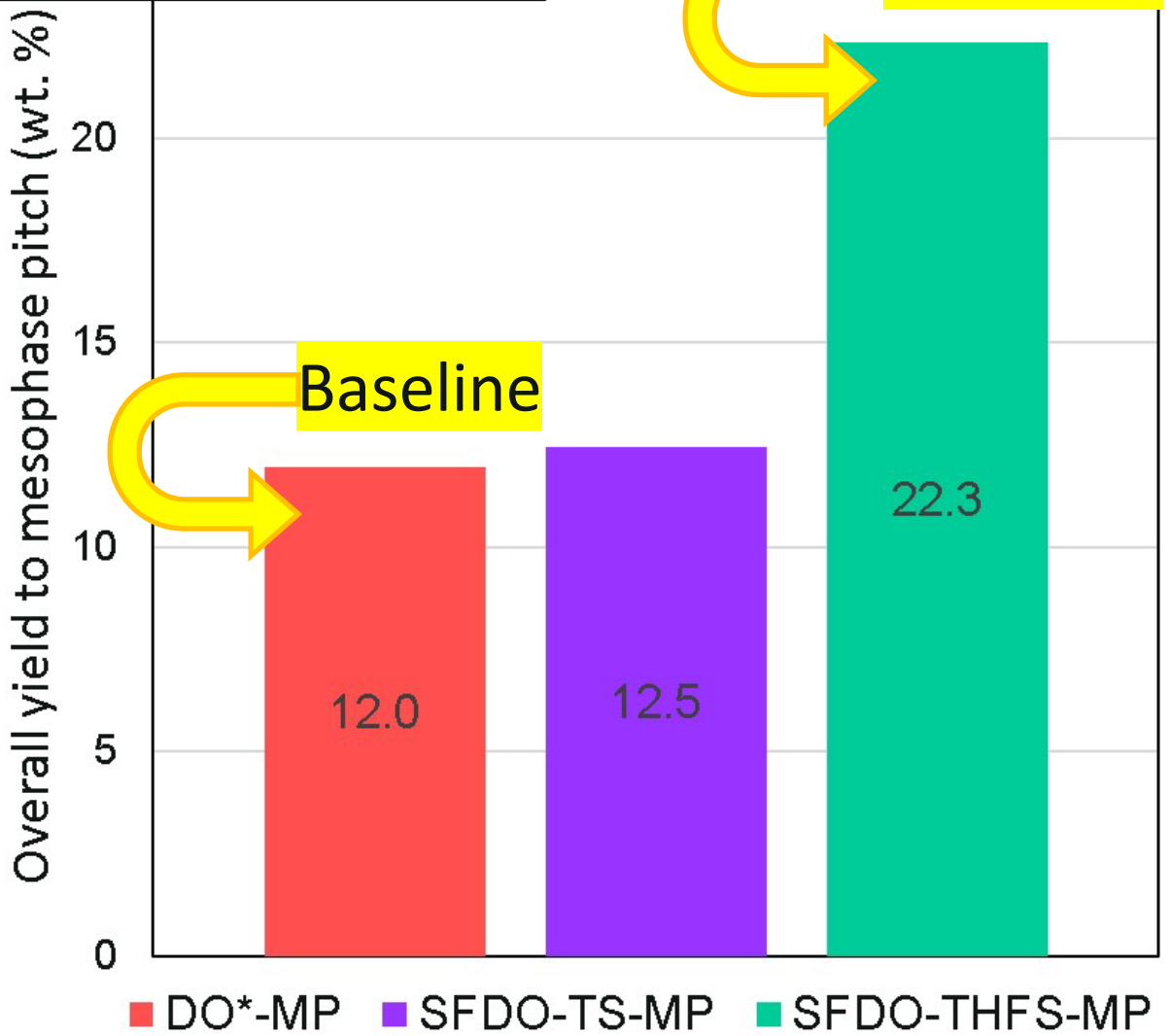
Example composite EV Battery Enclosure



CarMagazine.co.uk



86% YIELD INCREASE!



- High modulus (mesophase) carbon fiber achieved

Manuscript in review currently

Mesophase pitch-based high performance carbon fiber production using coal extracts from mild direct coal liquefaction

Christina Thompson^{a, b*}, George Frank^{a, c}, Vivian Edwards^a, Michela Martinelli^a, Asmund Vego^a, Frederic Vautard^d, Ercan Cakmak^d, John Craddock^a, Mark Meier^b, Rodney Andrews^{a, c}, Matthew Weisenberger^{a, c}

^aCenter for Applied Energy Research, University of Kentucky, 2540 Research Park Drive, Lexington, KY, 40511, USA

^bDepartment of Chemistry, University of Kentucky, Lexington, KY, 40506, USA

^cDepartment of Chemical and Materials Engineering, University of Kentucky, Lexington, KY 40506, USA

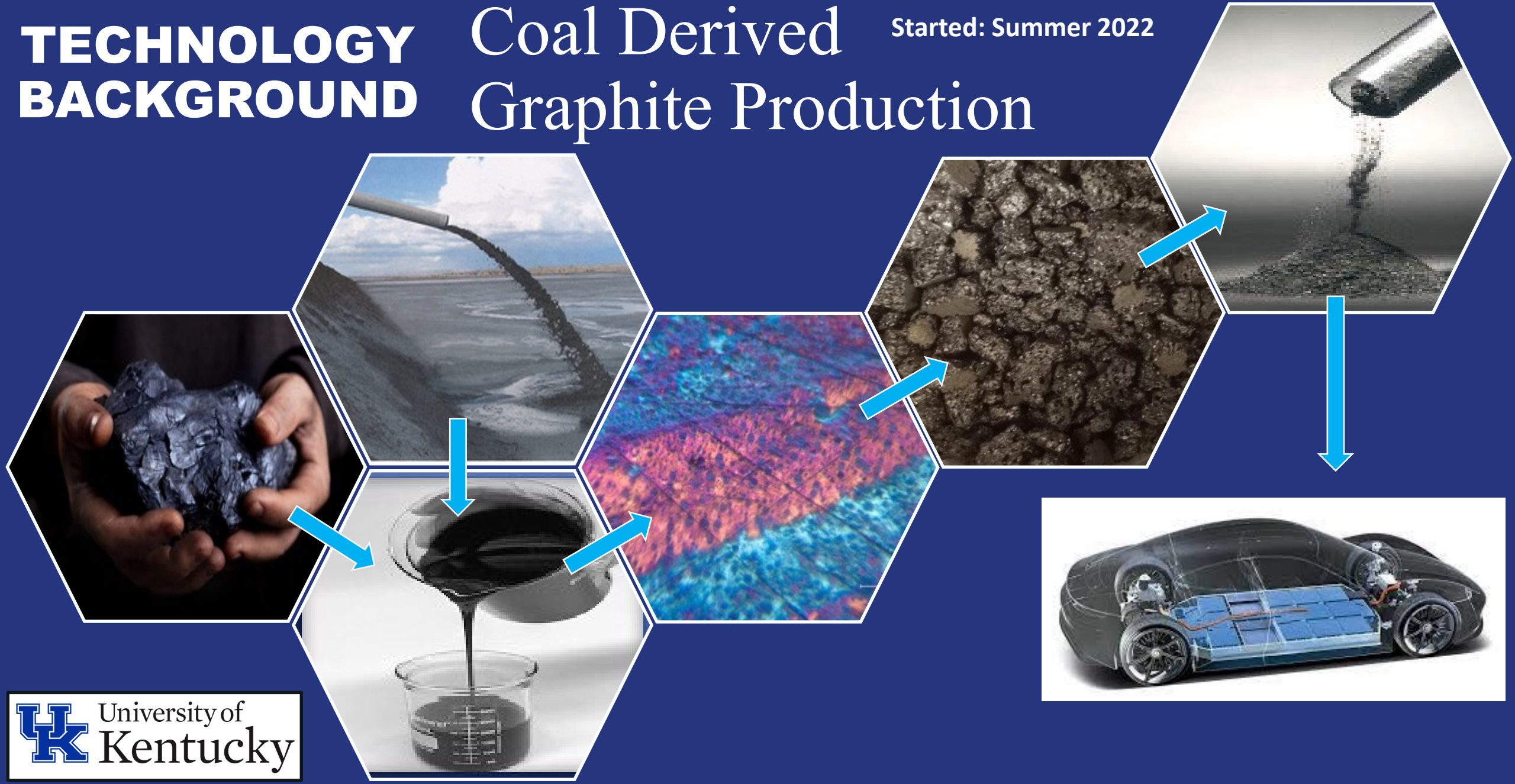
^dOak Ridge National Laboratory, 1 Bethel Valley Road, Oak Ridge, TN 37831, USA

- High modulus (mesophase) carbon fiber from waste coal achieved: manuscript in preparation
- We are currently investigating a variation of process for increases in coke production for graphite

TECHNOLOGY BACKGROUND

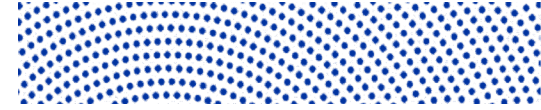
Coal Derived Graphite Production

Started: Summer 2022



C4Ward@Scale

Scaled-Up Coal Conversion for Carbon Fibers and Graphite



Three 12-month BPs



Finances & POI

Team Member	Federal Share of Costs (\$)	Non-Federal Share of Costs (\$)	Total (\$)
UK	\$4,669,907	\$1,250,000	\$5,919,907
% Share	78.88%	21.12%	100.0%



Tasks

1. Project Management and Planning
2. Coal to Products Facility Construction (**63% of budget**)
3. Coal Liquefaction and Filtration
4. Pitch and Green Coke Production
5. Solvent Recovery, Reuse and Process Optimization
6. Anode Grade Graphite Production
7. Carbon Fiber Production

PRODUCT 1: Scaled up, coal-derived isotropic pitches will be investigated as an alternative to *coal tar* binder pitch for the metals industry.

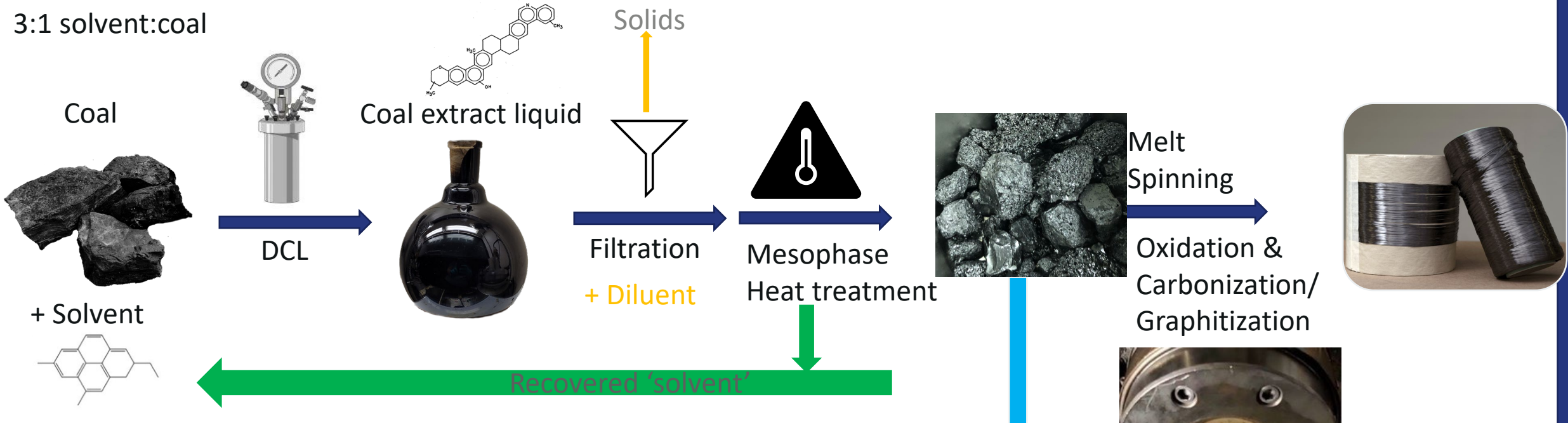
PRODUCT 2: Scaled-up coal-derived synthetic graphite will be investigated as an alternative to petroleum needle coke derived synthetic graphite for automotive battery manufacturing.

PRODUCT 3: Scaled-up coal-derived carbon fiber will be investigated cost effective reinforcement and/or insulation.

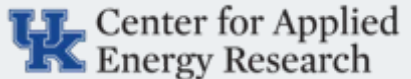
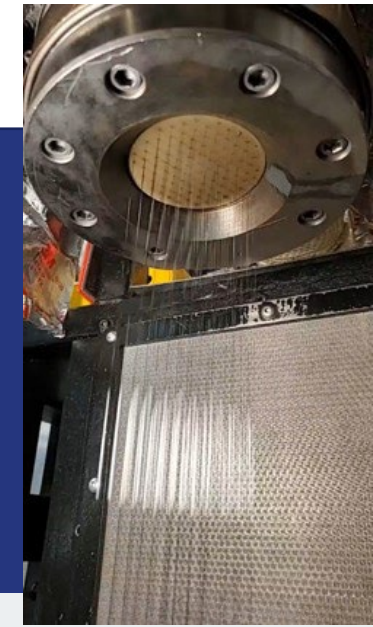
TECHNICAL APPROACH

Coal to Mesophase for Carbon Fiber

3:1 solvent:coal



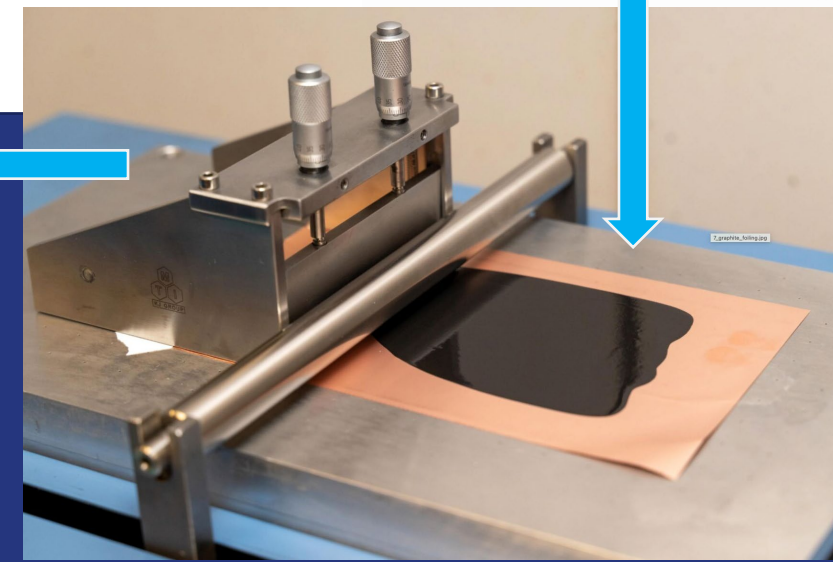
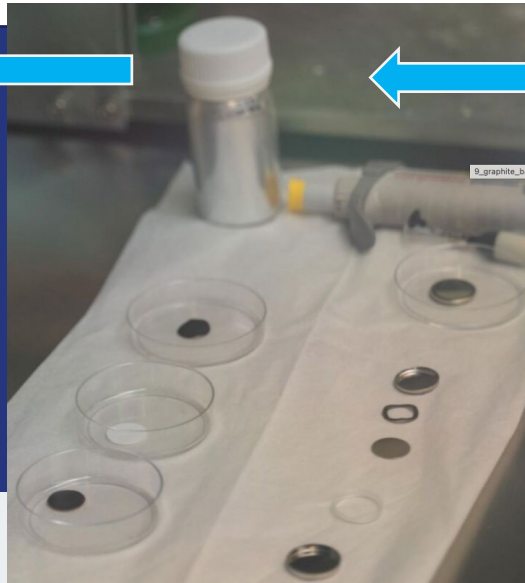
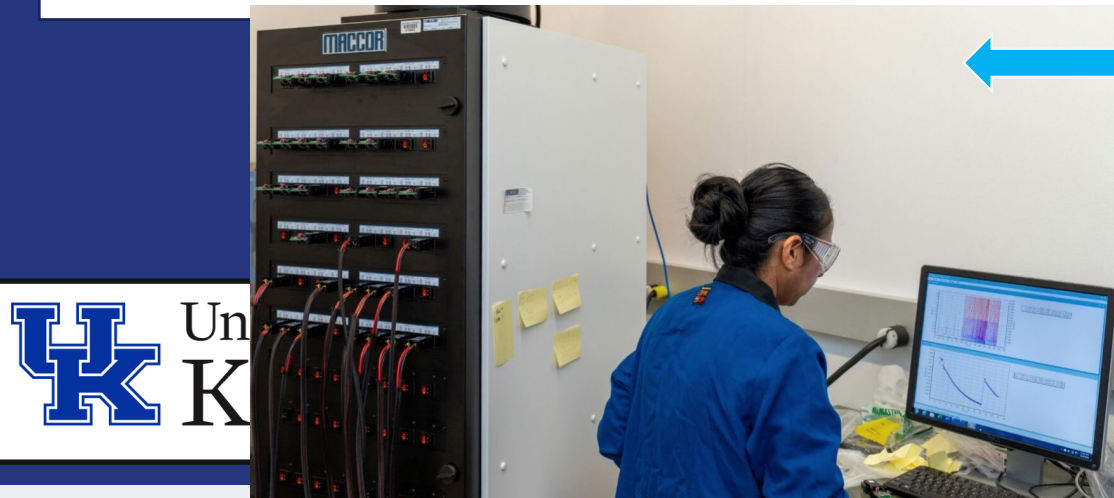
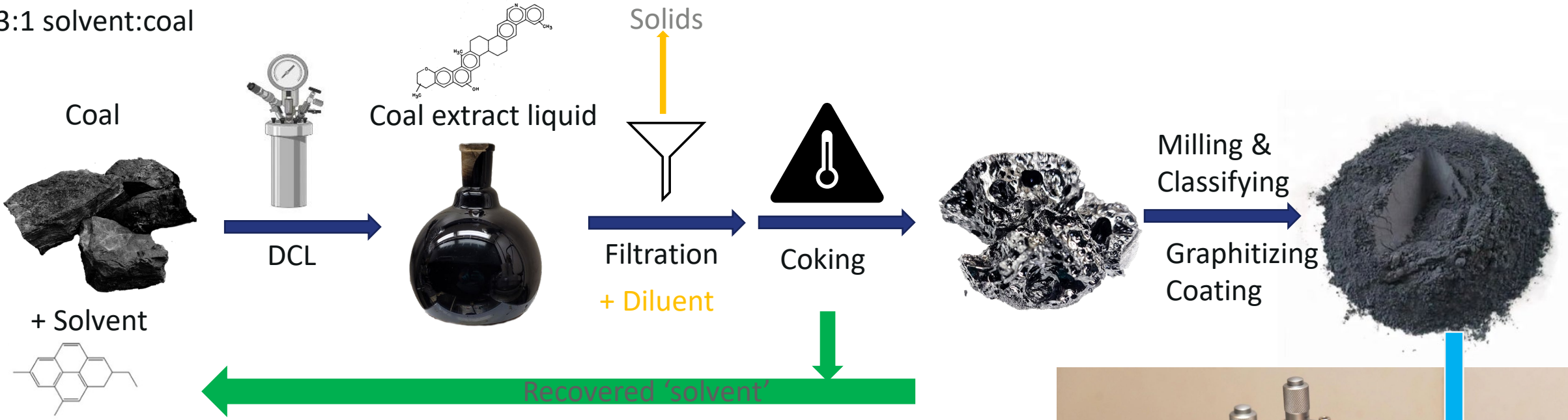
Scale up at CFTF



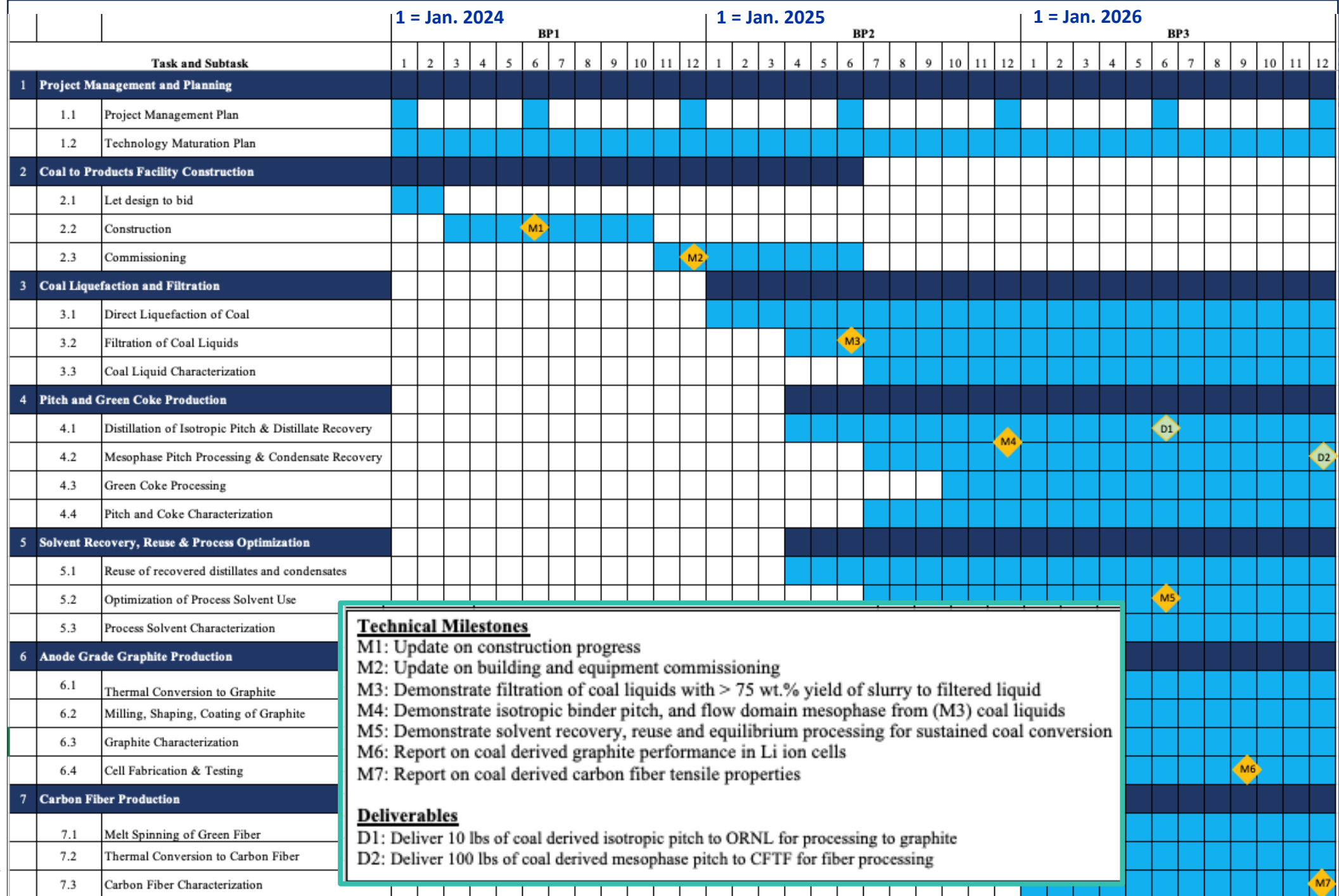
TECHNICAL APPROACH

Coal to Graphite for Energy Storage

3:1 solvent:coal



Gantt Chart



Technical Milestones

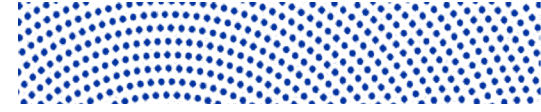
- M1: Update on construction progress
- M2: Update on building and equipment commissioning
- M3: Demonstrate filtration of coal liquids with > 75 wt.% yield of slurry to filtered liquid
- M4: Demonstrate isotropic binder pitch, and flow domain mesophase from (M3) coal liquids
- M5: Demonstrate solvent recovery, reuse and equilibrium processing for sustained coal conversion
- M6: Report on coal derived graphite performance in Li ion cells
- M7: Report on coal derived carbon fiber tensile properties

Deliverables

- D1: Deliver 10 lbs of coal derived isotropic pitch to ORNL for processing to graphite
- D2: Deliver 100 lbs of coal derived mesophase pitch to CFTF for fiber processing

PROGRESS and CURRENT STATUS

C4Ward@Scale: Scaled-Up Coal Conversion for Carbon Fibers and Graphite



1

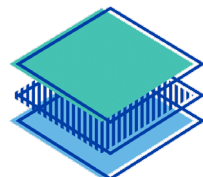
- Project kicked off: 20 March 2024
- Most of the scale-up equipment is in-storage in Lexington, KY (from 2021-2022)

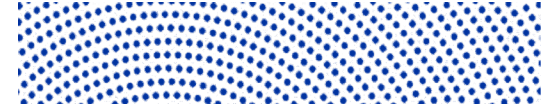
2

- Coal to Products Facility moving forward (picking up from initial work in 2021 – 2022)
 - Close collaboration with:
 - UK Capital Project Management Division (CPMD)
 - Omni Architects
 - Architectural DESIGN is finished
 - Mechanical & electrical DESIGN finished

3

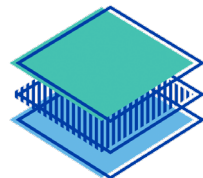
- Ongoing coal to carbon fiber & graphite work is serving to refine the existing scale-up process plan



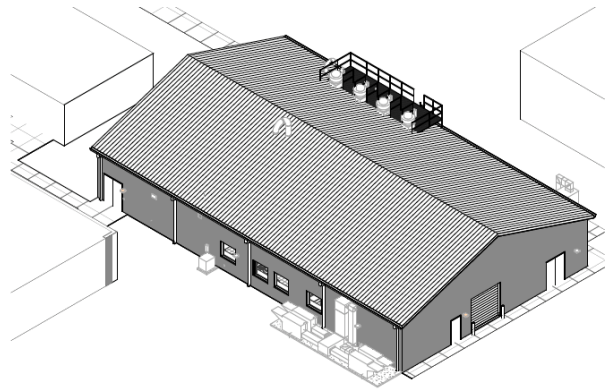


PLANS for FUTURE

Review of Tasks

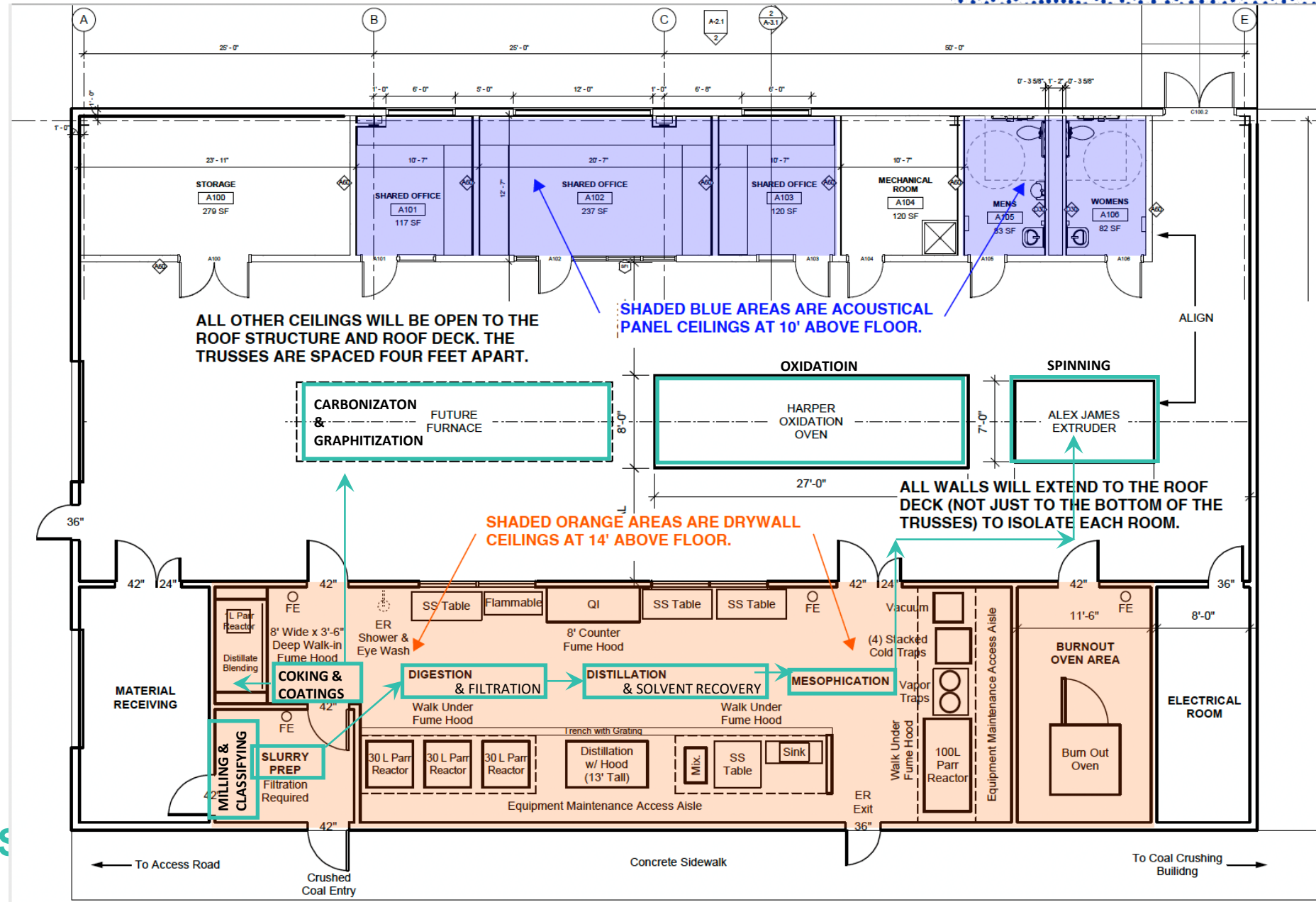


Task 2: COAL TO PRODUCTS FACILITY

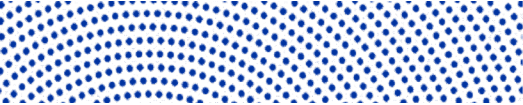


Goal:
Safe, efficient production of coal-derived mesophase pitch and anisotropic coke at the 100 lb/scale

- Supply to CTF

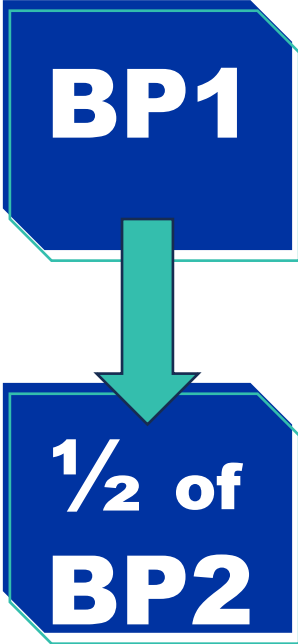


Task 2: Coal to Products Facility



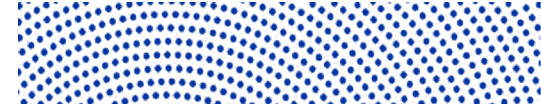
Schedule

Schedule



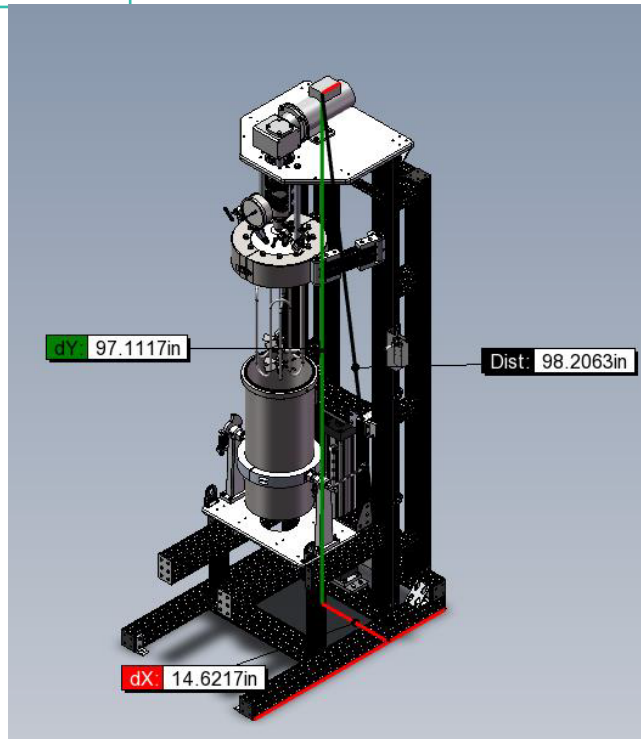
PROJECT SCHEDULE CONTROL - (2543) UK CAER - CARBON FIBER					UPDATED: 02/12/2024																		
MILESTONES	DURATION (DAYS)	START DATE	END DATE	2024												2025							
				J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J		
INTERVIEW / CONTRACT AWARD	?	10/13/20	?																				
SCHEMATIC DESIGN PHASE	28	06/03/21	07/01/21																				
PHASE 1 REVIEW	7	07/01/21	07/08/21																				
DESIGN DEVELOPMENT PHASE	42	07/08/21	08/20/21																				
PHASE 2 REVIEW	7	08/20/21	08/27/21																				
REMOBILIZATION	56	03/01/24	04/26/24																				
CONTRACT DOCUMENT PHASE	112	04/26/24	08/16/24																				
PHASE 3 REVIEW AND REVISIONS	28	08/16/24	09/13/24																				
ADVERTISE / BID / AWARD PHASE	45	09/13/24	10/28/24																				
CONSTRUCTION PHASE	224	10/28/24	06/09/25																				
MILESTONES	DURATION (DAYS)	START DATE	END DATE	2024												2025							
				J <th>F</th> <th>M</th> <th>A</th> <th>M</th> <th>J</th> <th>J</th> <th>A</th> <th>S</th> <th>O</th> <th>N</th> <th>D</th> <th>J</th> <th>F</th> <th>M</th> <th>A</th> <th>M</th> <th>J</th>	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J		

Task 3: Coal Liquefaction & Filtration

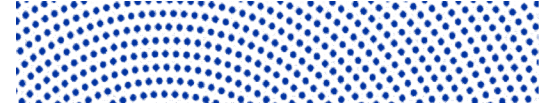


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1. Coal Slurry Processing
2. 3 – 30 L Coal Digest Systems
3. 3 – 13 L Filtration Systems
4. Coal liquid characterization

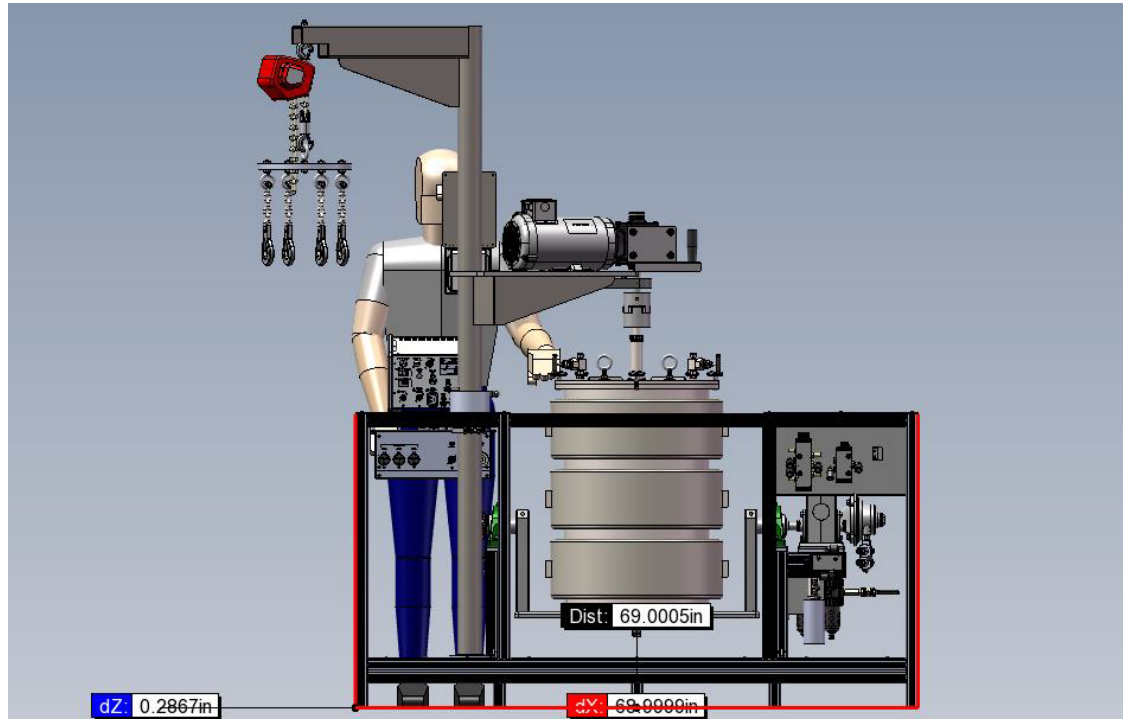


Task 4: Pitch and Green Coke Production

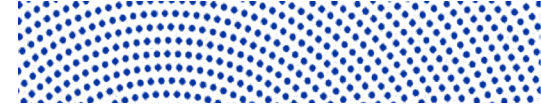


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1. 1 – 100 L Mesophase Reactor System
2. 1 – 50 L Distillation system
3. 1 – 2 L Coker System
4. Pitch and coke characterization



Task 5: Solvent Recovery, Reuse & Process Optimization

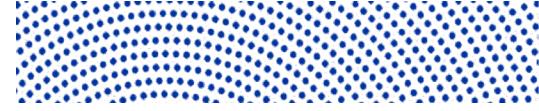


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- 1 – 50 L Distillation System
 - THF recovery for re-use
 - 1 – 20 L Rotovap System
- Recovered overheads from mesophase processing and coking to replace fresh decant oil (solvent)
 - Requisite for process economics
 - DO is far more \$\$ than coal at ~ \$700/t
- Recovered solvent characterization



Task 6: Anode Grade Graphite Production

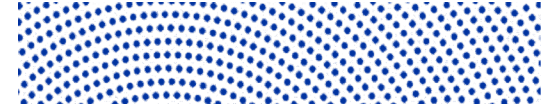


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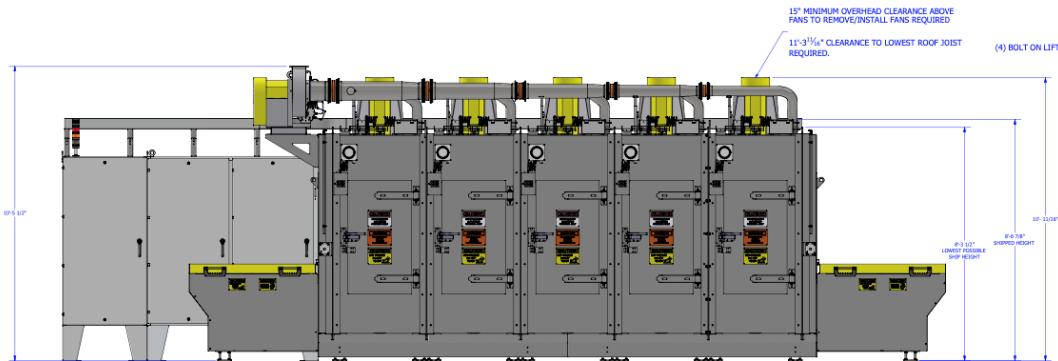
1. Calcining of green coke
2. Milling & Sieving
3. Graphitization
4. Characterization
5. Coating & Analysis in cells



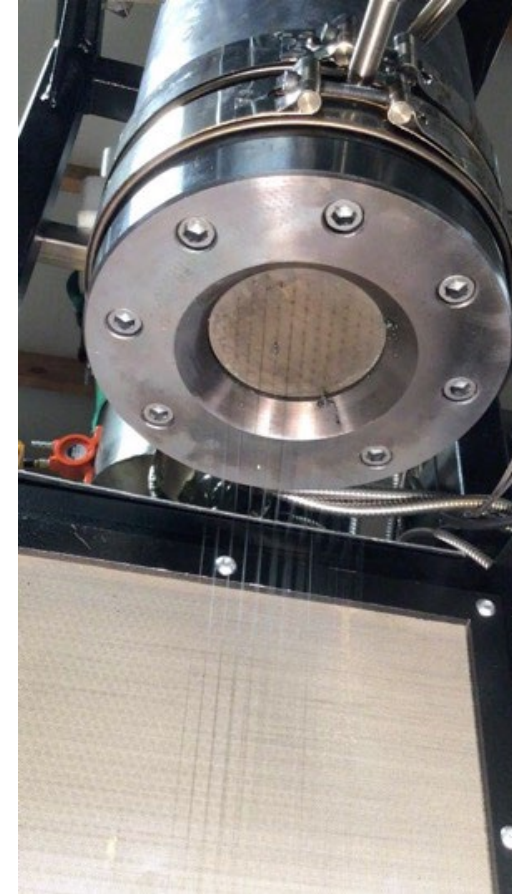
Task 7: Carbon Fiber Production



1. Melt Spinning
2. Thermal Conversion
3. Characterization

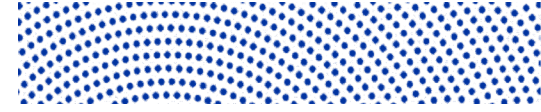


Oxidation system for green pitch fiber



SUMMARY: C4Ward@Scale

Scaled-Up Coal Conversion for Carbon Fibers and Graphite



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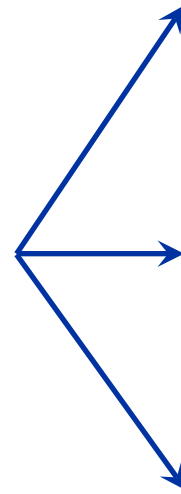
- Construction of the facility
- Commissioning the equipment

2

- Establishing processing at scale
- Optimization of processing
- Targeting
 - Up to 100 lb mesophase/month

3

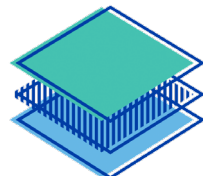
- Demonstrate utility and benefits of coal derived products
- Deliver pitch to ORNL / CFTF
 - Demonstrate coal products at pilot scale



PRODUCT 1: Scaled up, coal-derived isotropic pitches will be investigated as an alternative to *coal tar* binder pitch for the metals industry.

PRODUCT 2: Scaled-up coal-derived synthetic graphite will be investigated as an alternative to petroleum needle coke derived synthetic graphite for automotive battery manufacturing.

PRODUCT 3: Scaled-up coal-derived carbon fiber will be investigated cost effective reinforcement and/or insulation.



APPENDIX: Organization Chart

C4Ward@Scale: Scaled-Up Coal Conversion for Carbon Fibers and Graphite

1



- **Prime: University of Kentucky, Center for Applied Energy Research**
 - PI: Prof. Rodney Andrews
 - Col: Dr. Matthew Weisenberger and John Craddock
 - Mrs. Courney McCarthy



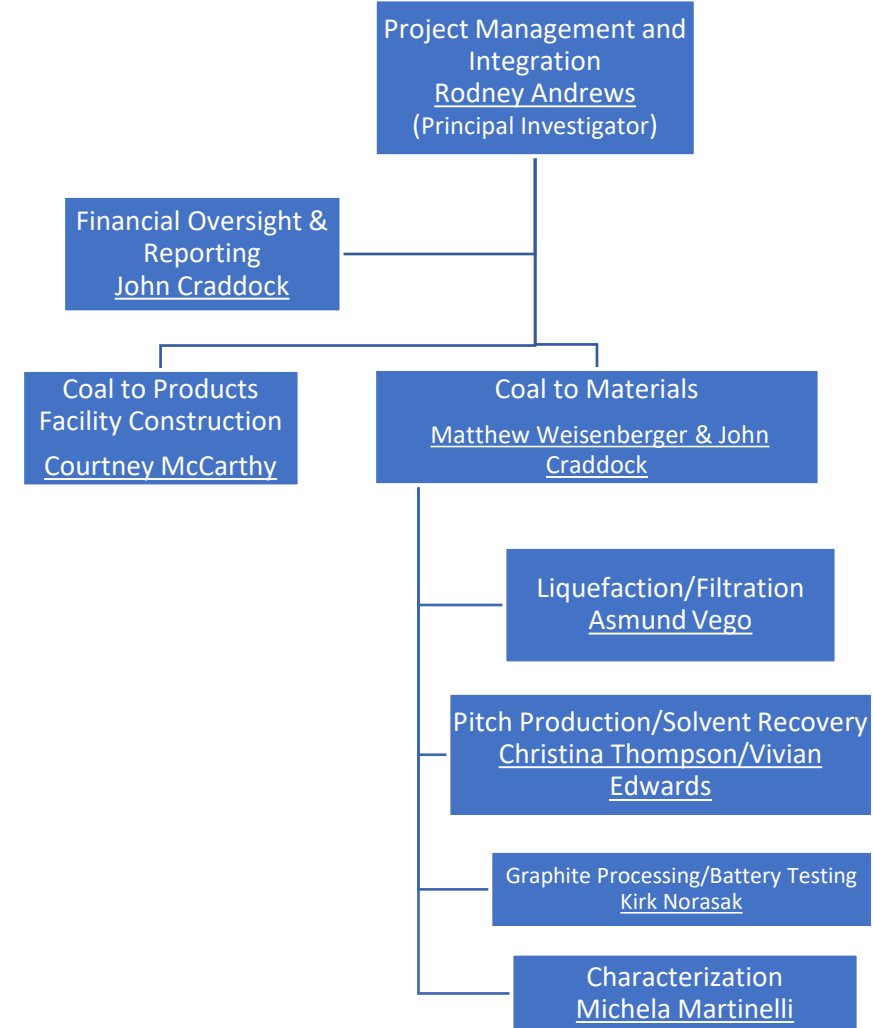
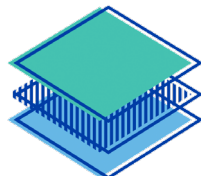
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CAPITAL PROJECT MANAGEMENT

- **UK Capital Projects Management Division (CPMD)**
 - Keith Ingram

UK CAER OUR MISSION



POWERFUL
Possibilities.

APPENDIX

Gantt Chart

Technical Milestones

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