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



Disclaimer

- Acknowledgment: "This material is based upon work supported by the Department of Energy Award Number DE-FE0032313."
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TECHNOLOGYCoal Derived**BACKGROUND**Coal DerivedCarbon Fiber Production

Prior work started: Summer 2020



Isotropic pitch-derived carbon fiber from waste coal

Carbon Volume 216, 5 January 2024, 118590

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

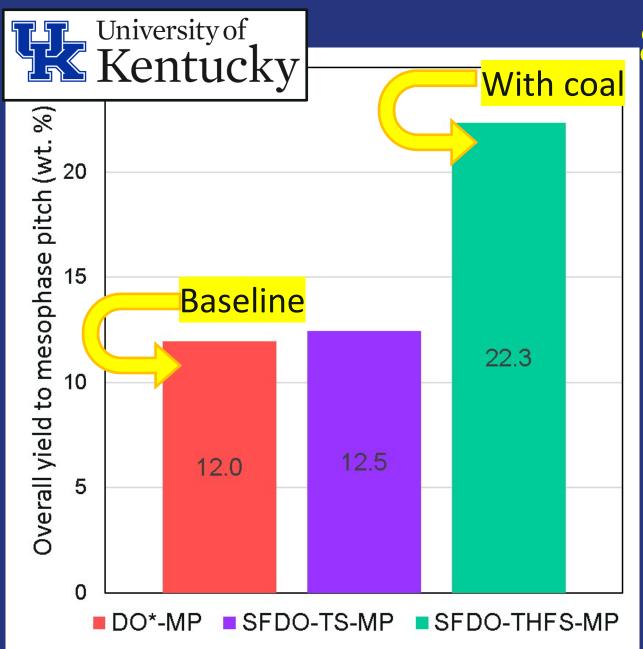




3kV 9.2mm x5.00

University of Kentucky

caer.uky.edu



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}

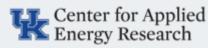
^aCenter for Applied Energy Research, University of Kentucky, 2540 Research Park Drive, Lexington, KY, 40511, USA

^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

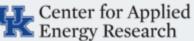


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TECHNOLOGYCoal DerivedStarted: Summer 2022**BACKGROUND**Graphite Production

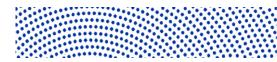






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C4Ward@Scale



Scaled-Up Coal Conversion for Carbon Fibers and Graphite

			Three 1	2-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

- L. 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

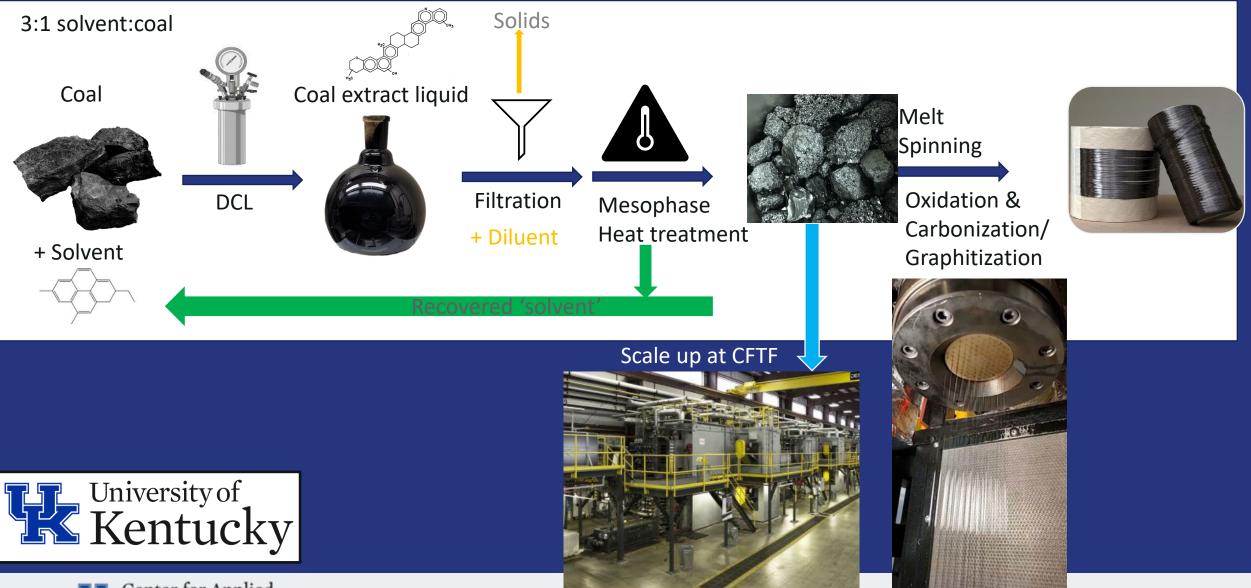
PRODUCT 1: Scaled up, coal-derived isotropic pitches will be investigated as an alternative to *coal tar* binder pitch for the metals industry.

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.

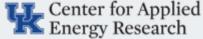
PRODUCT 3: Scaled-up coal-derived carbon fiber will be investigated cost effective reinforcement and/or insulation.



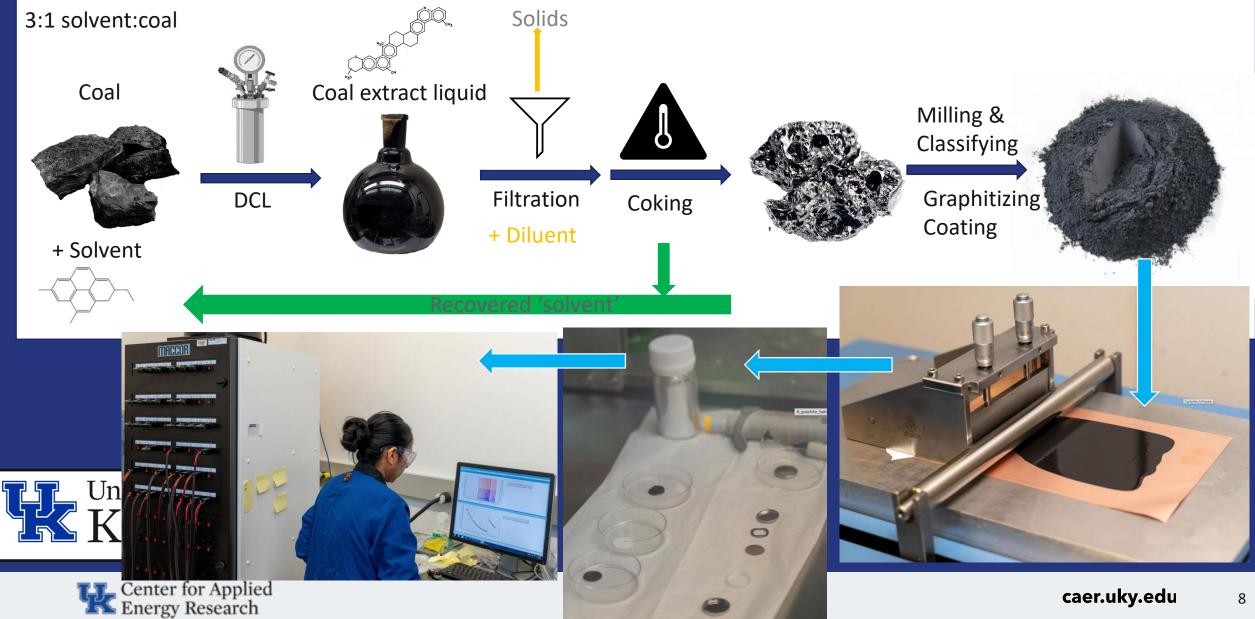
TECHNICAL APPROACH Coal to Mesophase for Carbon Fiber



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TECHNICAL Coal to Graphite for Energy Storage **APPROACH**



Gantt Chart

antt		1 = Jan. 2024												1 = Jan. 2025													Jan. 2026 BP3										
			Task and Subtask		1	2	3	4 5	6	7	8	9	10 1	1 12	2 1	2	3	4	5	6	7	8	9	10 1	1	12	1	2	3 4	5	6	7	8	9	10	11	12
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		1.2	Technology Maturation Plan																																		
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		2.3	Commissioning	-										N	2																						
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		3.2																		МЗ																	
		3.3	Coal Liquid Characterization																																		
	4	Pitch and	Green Coke Production																																		
		4.1	Distillation of Isotropic Pitch & Distillate Recovery																							<u>.</u>					0	1					
		4.2	Mesophase Pitch Processing & Condensate Recovery																																		D2
		4.3	Green Coke Processing																																		
		4.4	Pitch and Coke Characterization																																		
	5	Solvent R	ecovery, Reuse & Process Optimization																																		
		5.1	Reuse of recovered distillates and condensates																																		
		5.2	Optimization of Process Solvent Use																		-				ļ					=	N	5					
		5.3	Process Solvent Characterization	rization Technical Milestones																																	
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	7	Carbon F	iber Production																																		
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PROGRESS and CURRENT STATUS

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



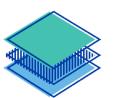
- Project kicked off: 20 March 2024
- Most of the scale-up equipment is in-storage in Lexington, KY (from 2021-2022)



- 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

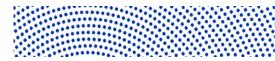


Ongoing coal to carbon fiber & graphite work is serving to refine the existing scale-up process plan





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



PLANS for FUTURE

Review of Tasks





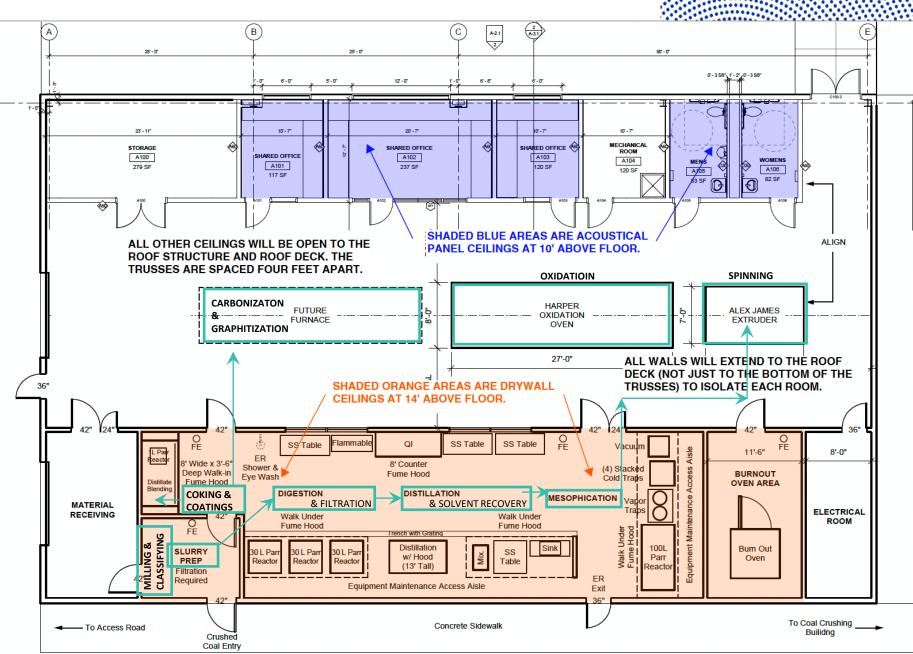
Task 2: COAL TO PRODUCTS FACILITY

Goal:

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

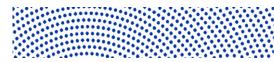
• Supply to CFTF

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Task 2: Coal to Products Facility



Schedule BP1 $1/_{2}$ of

Schedule

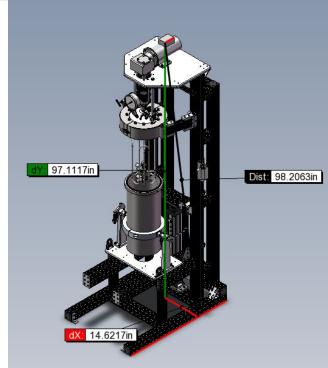
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INTERVIEW / CONTRACT AWARD	?	10/13/20	?																		
SCHEMATIC DESIGN PHASE	28	06/03/21	07/01/21																		
PHASE 1 REVIEW	7	07/01/21	07/08/21																		
DESIGN DEVELOPMENT PHASE	42	07/08/21	08/20/21																		
PHASE 2 REVIEW	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	START	END	J	F	М	Α	М	J	J	Α	S	0	Ν	D	J	F	М	Α	Μ	J
	(DAYS)	DATE	DATE						20)24								20	25		



Task 3: Coal Liquefaction & Filtration



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







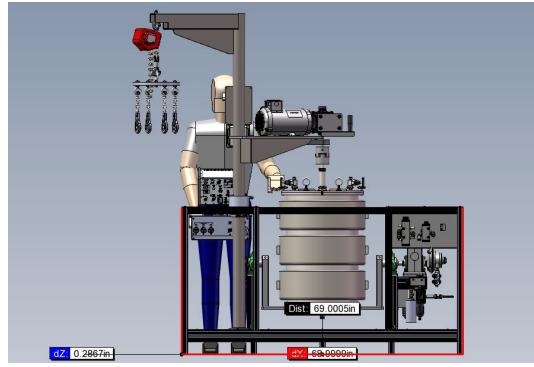




Task 4: Pitch and Green Coke Production



- 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

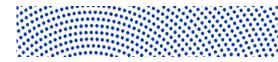


- 1. 1 50 L Distillation System
 - **1. THF recovery for re-use**
 - 2. 1 20 L Rotovap System
- 2. Recovered overheads from mesophase processing and coking to replace fresh decant oil (solvent)
 - **1.** Requisite for process economics
 - DO is far more \$\$ than coal at ~ \$700/t
- 3. Recovered solvent characterization





Task 6: Anode Grade Graphite Production





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





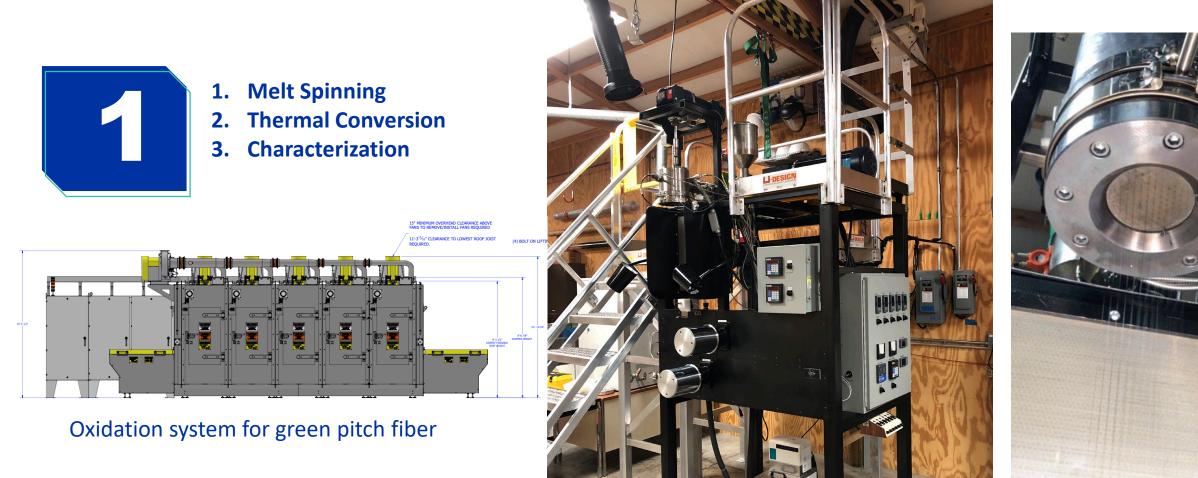




Task 7: Carbon Fiber Production



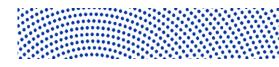
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SUMMARY: C4Ward@Scale

Scaled-Up Coal Conversion for Carbon Fibers and Graphite





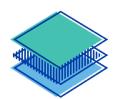
- Construction of the facility
- Commissioning the equipment

- Establishing processing at scale
- Optimization of processing
- Targeting
 - Up to100 lb mesophase/month



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

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PRODUCT 1: Scaled up, coal-derived isotropicpitches 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

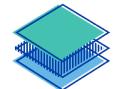
Center for Applied 💹 Energy Research **Project Management and** Integration **Rodney Andrews** (Principal Investigator) Prime: University of Kentucky, Center for Applied Energy **Financial Oversight &** Reporting John Craddock Coal to Products **Coal to Materials Facility Construction** Matthew Weisenberger & John **Courtney McCarthy** Craddock Liquefaction/Filtration Asmund Vego Pitch Production/Solvent Recovery Christina Thompson/Vivian Edwards Graphite Processing/Battery Testing **Kirk Norasak** Characterization Michela Martinelli OWERFUL

PI: Prof. Rodney Andrews Col: Dr. Matthew Weisenberger and John Craddock ۲ Mrs. Courney McCarthy **Facilities** CAPITAL PROJECT Management MANAGEMENT **UK Capital Projects Management Division (CPMD)** Keith Ingram

Center for Applied

Energy Research

Research



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