UCFER- An Economically-Viable Technology for Production of Coal-derived Aerogel Insulation Envelope

University of Kentucky
Center for Applied Energy Research
Lexington, KY
http://www.caer.uky.edu/powergen/home.shtml

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Objective

To develop An Economically-Viable Technology for Production of Coal-derived Aerogel Insulation Envelope (Thermal Resistance R-values of 14 to 105)

Outline

• Background
• Objective
• Approach
• Project Details
DOE believes that advances in coal-derived building materials, such as carbon foam (graphitic or non-graphitic), roofing tiles, siding, insulation etc can be a viable way to provide:

- Lower price or superior properties to existing building materials
- New value-chain of industrials that do not use coal in manufacturing process.
- Reduce GHG (CO₂) emissions
Background
Evolution of Aereogel

Compared to single component aerogel, plastic/metal oxide reinforced aerogel combined better flame retardance, physical strength and thermal conductivity

R-value: 0.024 W/m/K
BET: >200 m²/g
>95% macroporosity
>500 °C stable
Background

Federal and Industrial Programs

EERE- BTO report

Provided by industrial partners

Less than 1” of aerogel-based insulation is equivalent to 3” of fiberglass. The aerogel-based insulation also requires 20% less cladding and binding.
Background

General Approaches for Carbon Aerogel Foam

Step 1: Sol-gel process
- Reactants
- Colloidal particle
- Solvents
- Catalyst
- Time
- Liquid
(a) Sol
Dispersion of colloidal particles

Step 2: Aging
- Colloidal
3-dimensional grid
(b) Gel
Continuous network of colloidal particles

Step 3: Drying
- More perfect continuous network

Step 4: Carbonization
- 600-2500 °C
- 3-10 hours
- Inert atmosphere
(c) Gel
(d) Aerogel
(e) Carbon aerogel

+ Step 4 is not necessary for current program because of physical strength is necessary
+ Coal depolymerization is the most critical step:
  Concentrated HCl/HNO₃ solvent
>120 °C operation, >24 hour reaction, four steps

Nature Communication 2013
Objective

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• Demonstration of depolymerization of coal into carbon nano-particle under mild condition: (<150 °C, <2 hour, <0.3MPa)

• Validate production of PVC (~15%) or Clay- reinforced carbon aerogel production
  (yield >30%, >1Kg/day, density ~2.4 g/cm3 and BET area 300 m²/g.)

• Thermo-mechanical characterization of coal-derived aerogel envelopes
Summary of Patented Technical Approach

WO 2021041897 and US 2019-62893385

Dr. Tian and George Institute of Technology
Success Validation of Carbon Quantum Dots Production from Coal
Success Validation of Carbon Aerogel (Foam) for Carbon Nanoparticles
Success Validation of Coal-derived Building Envelope, Carbon Foam, and Carbon Fibers Developed in Dr. Tian’s Lab
# Project Schedule

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<td>Tian, NETL</td>
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Collaboration Work with NETL

+ NETL’s multiple-wavelength Raman or in-situ SEM/TEM

+ Technical/economic communication

+ Technical discussion with Research Team, possibly with industrial partners
Acknowledgements

Bruce Miller (Penn State) and Omer Bakshi (NETL)
All UCFER Management

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Dr. Kunlei Liu