Unique Nanotechnology Converts Carbon Dioxide to Valuable Products

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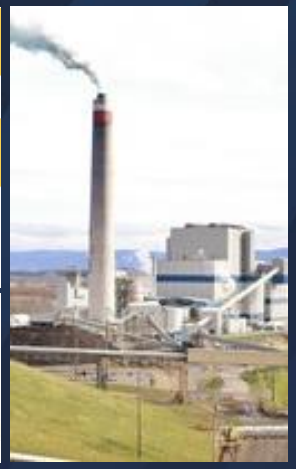
(A). Project Overview

Funding: DOE-NETL: $800,000; Cost-share: $218,205

Project Team and Industry Sponsor:

- Bingyun Li, PhD (PI, WVU)
- Badie Morsi, PhD (Co-PI, Univ. of Pitt)
- Jingxin Wang, PhD (Co-PI, WVU)
- Ron Rosinski (Longview Power, LLC)
- Trina Wafle (Coordinator, WVU)
- Andy Aurelio (Project manger, NETL)



Overall Project Objective:

- To develop and test an innovative bicarbonate nanotechnology that can utilize CO_2 from coal-based power systems or other industrial sources as the primary feedstock to produce commercially valuable products.

Overall Project Performance Dates:

Task	Start	Finish	19				20				21			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1 – Project management and planning	1/1/19	12/31/21	◊D1			◊				◊				◊
Task 2 - Technology maturation plan	1/1/19	6/30/19		D2										
Task 3 - Lab-scale unit modification	4/1/19	3/31/20												
Task 4 - Selection of best candidate amino acid solution	4/1/19	3/31/20					M1							
Task 5 - Process optimization to produce high-purity nanomaterials	1/1/20	11/30/21												M2
Task 6 - Life cycle analysis	4/1/19	12/31/21											D3(M3)	
Task 7 - Technical and economic feasibility study	4/1/19	12/31/21											D4(M4)	

◊ Kickoff meeting and annual briefings.
Deliverables: D1 – Updated PMP; D2 – Updated TMP; D3 – Completed TCA; D4 – Completed TEA.
Milestones: M1 – Identified the best candidates; M2 – Completed optimization process; M3 – Completed LCA; M4 – Completed TEA.

(B). Technology Background

❑ Solvent preparation

$$\underset{\text{low pH}}{HOOC\text{-}R\text{-}NH_3^+} \xleftrightarrow{-H^+} \underset{\text{neutral - mildly acid pH}}{{}^-OOC\text{-}R\text{-}NH_3^+} \xleftrightarrow{-H^+} \underset{\text{high pH}}{{}^-OOC\text{-}R\text{-}NH_2}$$

$$^-OOC\text{-}R\text{-}NH_3^+ + NaOH \longleftrightarrow Na^+ + {}^-OOC\text{-}R\text{-}NH_2 + H_2O$$

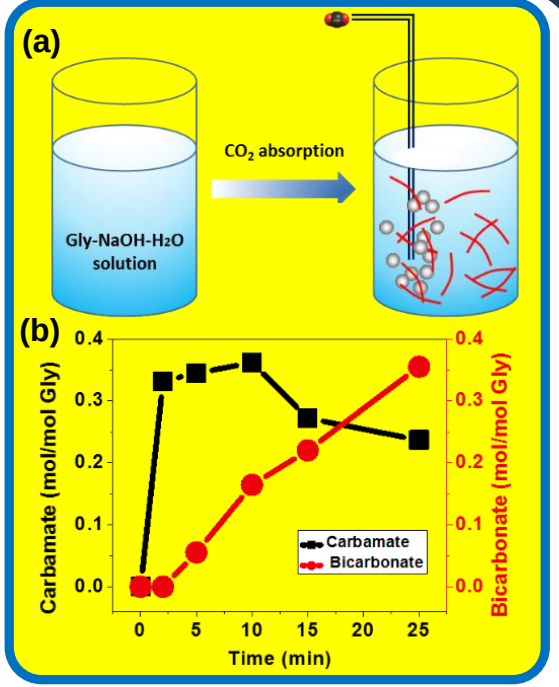
❑ Reactions with CO_2

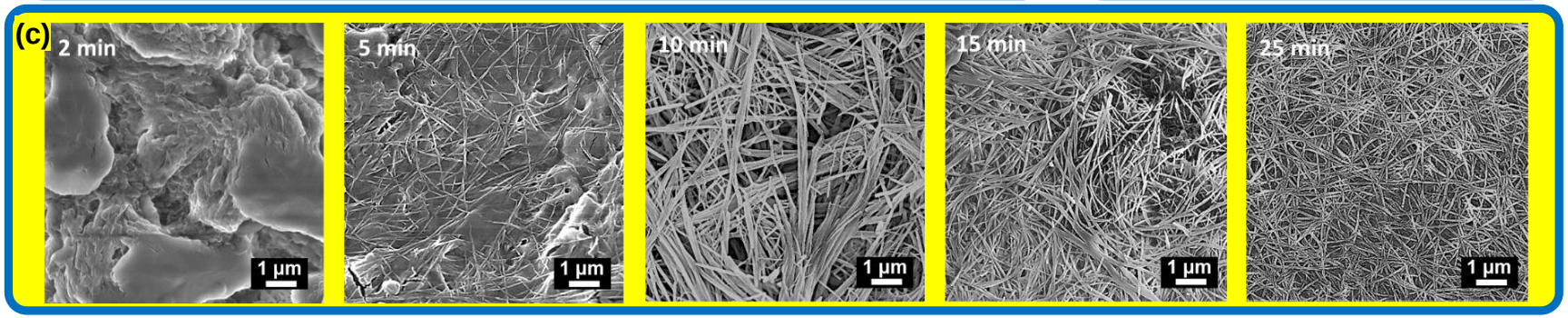
Carbamate formation

$$CO_2 + 2Na^+[{}^-OOC\text{-}R\text{-}NH_2] \longleftrightarrow \underbrace{[Na^+]_2[{}^-OOC\text{-}R\text{-}NH\text{-}COO^-]}_{\text{Carbamate}} + \underbrace{{}^-OOC\text{-}R\text{-}NH_3^+}_{\text{Zwitterion}}$$

Carbamate hydrolysis

$$[Na^+]_2[{}^-OOC\text{-}R\text{-}NH\text{-}COO^-] + H_2O \longleftrightarrow \underbrace{Na^+[{}^-OOC\text{-}R\text{-}NH_2]}_{\text{Amino acid}} + \underbrace{NaHCO_3}_{\text{Bicarbonate}}$$

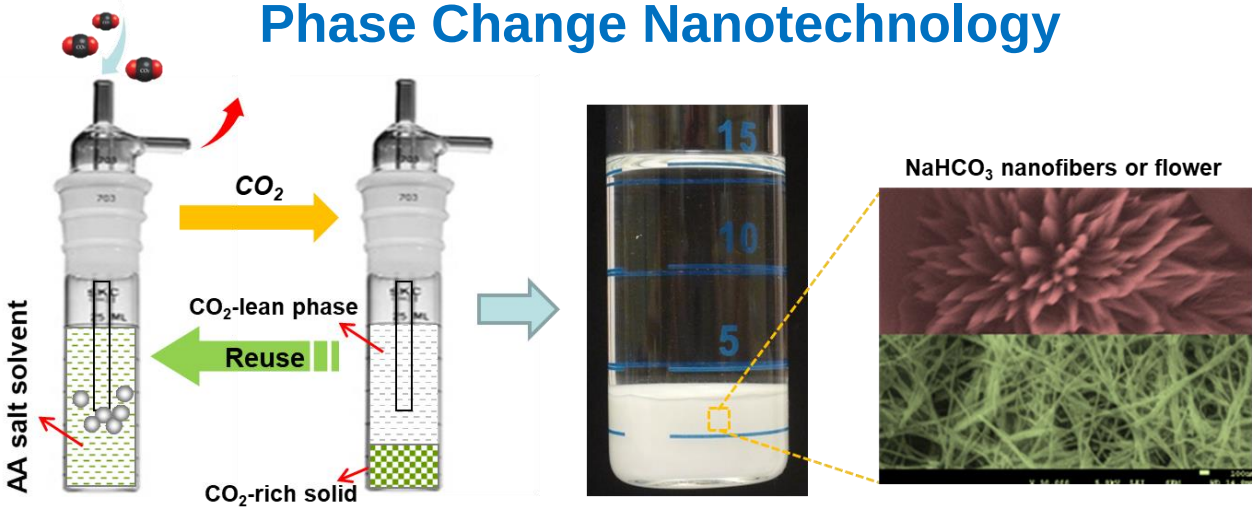




Amino acid salt solvent converts CO_2 into nanofibers. (**a**) Schematic diagram. (**b**) Species changes and (**c**) SEM images at various times.

(C). Technical Approach

Phase Change Nanotechnology



Major Task	Milestones/Success Criteria	End Date
Effects of contaminants on nanomaterial formation	Have found that the contaminants have limited impact on the CO_2 conversion to nanomaterials.	03/31/20
Strategies to obtain high-purity nanomaterials	Have developed and optimized a pathway to obtain high-purity (99% or higher) sodium bicarbonate nanomaterials.	11/30/21
Process design and economic and life cycle analyses	Have assessed that the proposed approach has CO_2 reduction potential in life cycle analysis and the process is economically feasible.	12/31/21

Acknowledgement

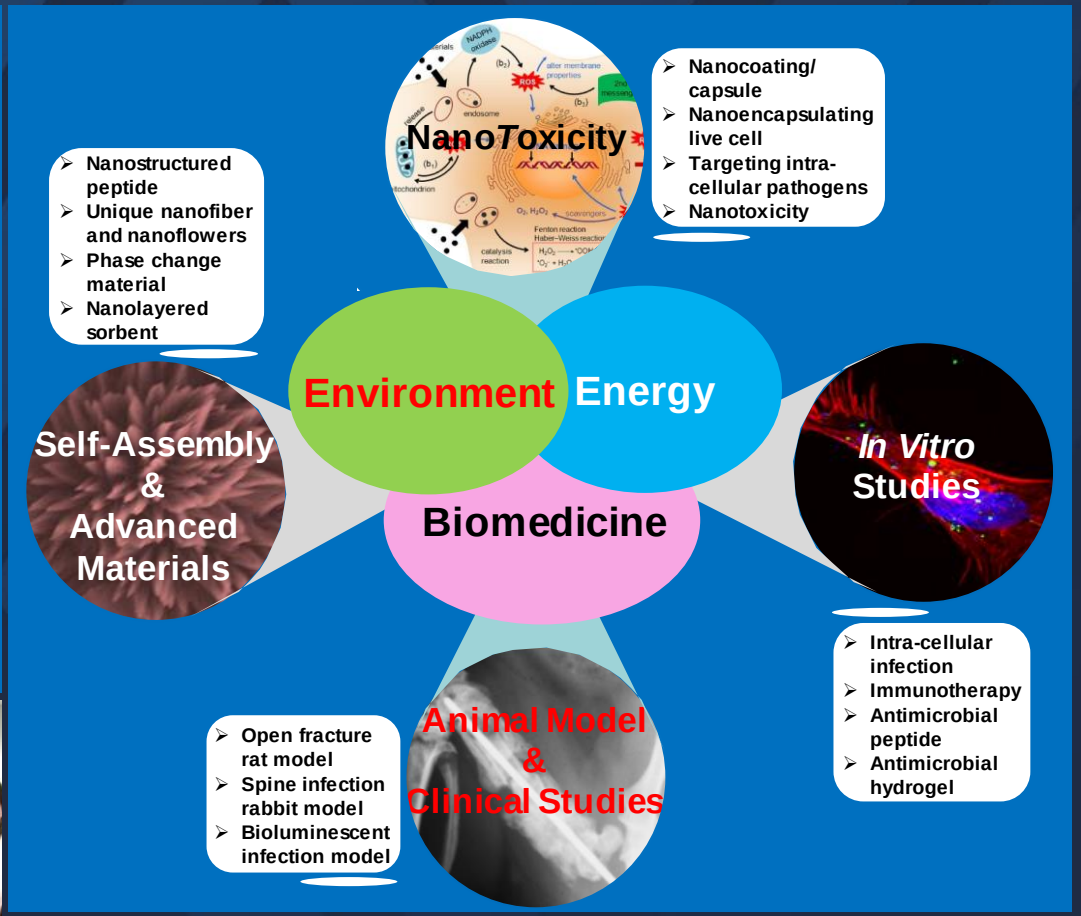
Funding: DoE/NETL

Trainees: 102 (since 2005)

Research Staff: three

Collaborators: Badie Morsi, Jingxin Wang, Trina Waffle, Ron Rosinski, David Hopkinson, Mac Gray, Kevin Resnik, James Hoffman, Yuhua Duan, Daniel Fauth, Henry Pennline, George Richards, …

NETL managers: Andy Aurelio



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